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UTILIZATION OF OHIO RIVER SHALLOW WATER HABITATS BY YOUNG-OF-THE YEAR FISHES

by

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ABSTRACT

Between 9 June and 11 November, 1981 and 9 June and 8 October, 1982, 149 samples were collected from selected backwater and mainstem sites of the middle Ohio River (between river mile 339 and 424). Sites were collected at approximately tri-weekly intervals during 1981 and bi-weekly intervals in 1982 using a 10m x 2m bag seine with 2m x 2m bag, 5.5mm ace mesh wings, and 2mm ace mesh bag. Analysis of young-of-the-year fishes collected indicates that backwaters are more important than mainstem martins in terms of number of species supported, relative frequencies and comparative densities. Total number of species collected from backwaters was fifty-four, from mainstem margins forty two. Twenty-one species were collected in sixty percent or more of the backwater samples, compared to six species collected in sixty percent of samples for mainstem margins. Comparative densities as analyzed by the T-test were significantly higher (at the 0.5 level) for a greater number of species in backwaters (16) than mainstem margins (0). In terms of relative abundance, emerald shiners (Notropis atherinoides) dominated mainstem margins (96% of total numbers collected). Others present in high relative abundance for mainstem margins included gizzard shad (Dorosoma cepedianum - 1.5%), mimic shiner (Notropis volucellus - 1.3%), and river shiner (Notropis blennius - 1.0%). Many species were present in relatively high abundances in backwaters. Gizzard shad (D. cepedianum) and emerald shiners (N. atherinoides) comprised the majority of fishes collected (54% and 23% respectively), followed by mimic shiner (N. volucellus - 5.0%), bluegill (Lepomis macrochirus - 4.0%), silver chub (Hybopsis storeriana - 3.0%), bluntnose minnow (Pimephales notatus - 2.0%), river shiner (N. blennius - 2.0%), freshwater drum (Aplodinotus grunniens - 1.7%), bullhead minnow (Pimephales vigilax - 1.2%), ghost shiner (Notropis buchanani - 0.6%), white bass (Morone chrysops - 0.6%), river carpsucker (Carpiodes carpio - 0.5%), longear sunfish (Lepomis megalotus - 0.5%), sauger (Stizostedion canadense - 0.4%), spotted bass (Micropterus punctulatus - 0.3%), golden redhorse (Moxostoma erythrurum - 0.2%), and spotfin shiner (Notropis spilopterus - 0.2%).

Dietary habits of the fourteen most abundant young-of-the-year species from 1982 were examined over three dates (21 July, 26 August, and 7 October) during the course of the 1982 summer period. These species included N. atherinoides, D. cepedianum, N. volucellus, L. macrochirus, N. blennius, H. storeriana, P. notatus, A. grunniens, P. vigilax, M. chrysops, C. carpio, L. megalotus, M. punctulatus, and S. canadense. A total of 26 different items were found to be consumed by the above species. Analysis of diet-overlap was performed using the Schoener Index. Those species which exhibited significant diet overlap (above 0.60) included the following species pairs: N. volucellus - D. cepedianum; P. notatus - D. cepedianum; P. vigilax - H. storeriana; A. grunniens - H. storeriana; L. megalotis - H. storeriana; P. notatus - N. volucellus; P. notatus - P. vigilax; M. punctulatus - M. chrysops; S. canadense - M. chrysops; S. canadense - M. punctulatus; and L. megalotus - A. grunniens.

Summer growth rates of the fourteen most abundant young-of-the-year species from 1982 was also examined. Fish were measured using total length. Determination of growth rate was also performed. In general growth of young-of-the-year was comparable to that reported by other authors for other geographical areas. Noticeably slower growth was found in the freshwater drum (A. grunniens), noticeably higher growth in the white bass (M.

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INTRODUCTION

The need to assess the role shallow water habitats (ie. the mainstem margins and backwaters) play in the life cycle of young-of-the-year fishes is of major importance to those interested in the overall ecology of fishes in the Ohio River. The presence or absence of a particular species in a particular habitat of the river, together with the basic biological information (ie. the trophic habits, dietary relationships, and growth rates) of that species, are areas which need examination. Which type of habitat (ie. the mainstem margin or backwater) is most important as nursery areas to young-of-the-year fish? What types of fish inhabit these areas? What do young-of-the-year fishes in the Ohio River feed upon? Do young-of-the-year fishes exhibit dietary overlap or resource partitioning? What is the growth rate of young-of-the-year fishes in these habitats? These are all questions that need answering. Therefore, the objective of this study is to answer the questions concerning species composition, dietary habits, dietary overlap, and growth rate of the young-of-the-year fishes in shallow water habitats of the Ohio River.

Few published reports have been made concerning the shallow water habitats of the Ohio River in regards to their importance to young of the year fishes. Shallow water habitats; the beaches, river mouth areas, and embayments (flooded feeder streams) created by impoundment; have not been surveyed extensively for the presence of young of the year fishes on the Ohio River although these areas probably play an important role in the life cycle of many fishes. In those studies which have examined fish populations in shallow water habitats of the Ohio River (Yoder and Gammon 1976, Krumholz and Minckley 1964) the emphasis has been on adult fishes with little data presented on young-of-the-year. Recent studies by Wagner et.al. (1980) Miller et al. (1981) and Moller (1983) have dealt with larval fish populations of the Ohio River. Wagner et al. (1980) presented data on the pattern and length of appearance of several larval fish species near Maysville, Kentucky. Wagner et al. (1981) and Moller (1983) evaluated backwater and mainstream origins of larval fish in the Ohio River and found backwaters important as breeding habitats based on analysis of size class frequencies and relative frequencies of larval fish collected during the summer of 1981.

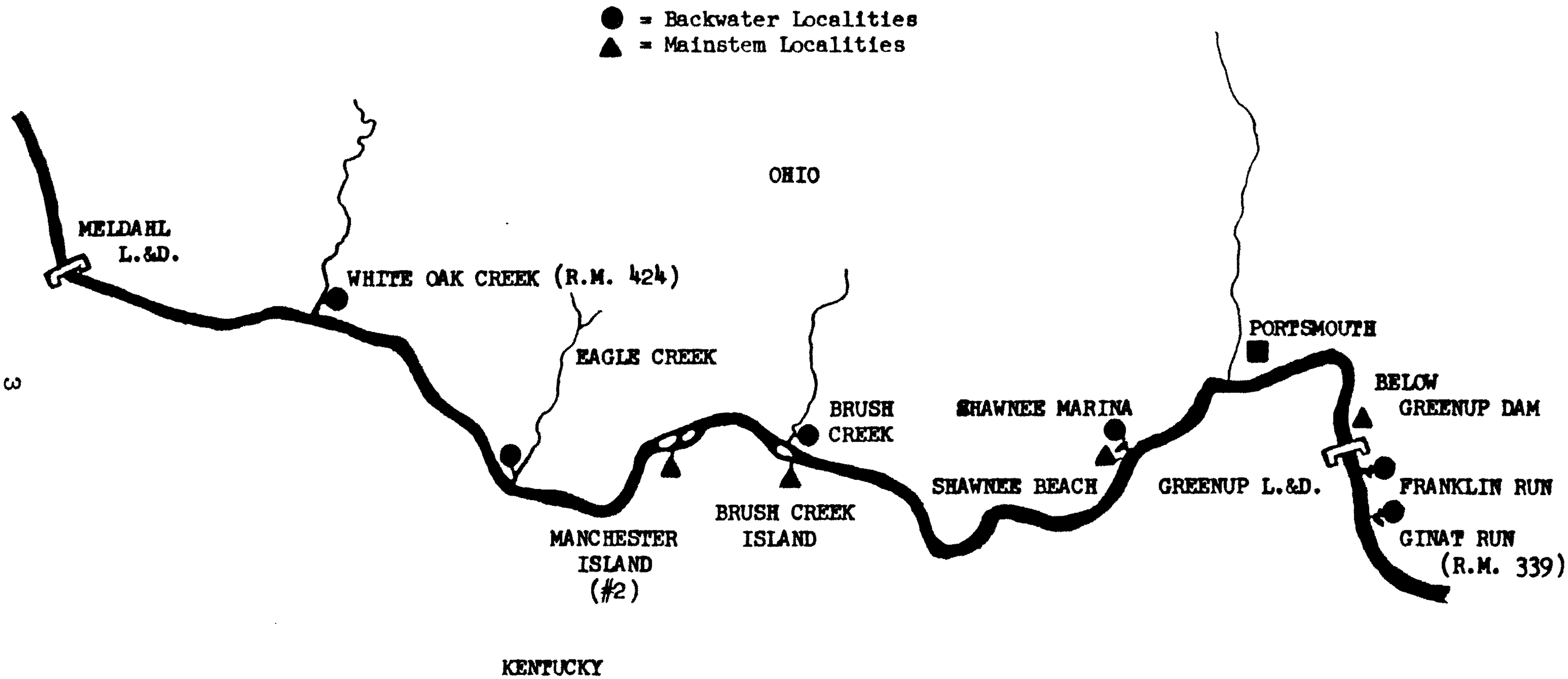
The majority of fish population survey work on the Ohio River has been completed through dam lock chamber (considered part of the river mainstem channel waterway) roetenoning by the Ohio River Valley Water Sanitation Commission (ORSANCO). ORSANCO (1962) sampled dam lock chambers and selected areas in their survey of the aquatic-life resources of the Ohio River. ORSANCO (1980) has surveyed dam lock chambers from 1968 through 1980 as part of their annual surveillance of fish populations of the Ohio River. Preston and White (1978) summarized Ohio River fishery data (from ORSANCO data) for the years 1968-76. The fish sampled in these surveys are mainly adult although young-of-the-year have been included as part of the overall data.

Several studies of fish populations of the Ohio River have been the result of power plant impact studies. Examples include the works by Hatch and Gammon (1973), Lesniak and Gammon (1974), Norris and Gammon (1971), Yoder and Gammon (1975), and Yoder and Gammon (1976). Young-of-the-year were not given special consideration in any of these studies.

STUDY AREA

The Ohio River is formed by the confluence of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania. It flows a distance of 1580 kilometers (981 miles) to its' junction with the Mississippi River at Cairo, Illinois. Approximately 40,500 hectares (100,000 acres) surface area of water is found in this distance (Preston and White 1978).

Figure 1: Sampling Localities for Ohio River Young-of-the-Year Fish Survey (1981-82).



The Ohio River basin is composed chiefly of sedimentery rock. Composistion varies from siltstone and shales to limestone and sandstone. The river flows through a narrow valley for most of its' range Banks are mostly steep and there are few shallow wetland areas (Preston and White 1978). Presently 20 high lift navigation dams have modified the Ohio River into a series of slack water navigation pools.

Eleven (five river mainstem and six backwater) study sites were selected along a ninety mile stretch of the middle Ohio River (between river mile 339 and 424, see Figure 1 for location of sampling localities). Sites were selected in order to incorporate all major river habitats available to young of the year fishes with the exception of open water areas which were not available to the techniques used.

METHODS AND MATERIALS

Collection Methods:

Sites were collected using a 10m x 2m bag seine with 2m x 2m bag, 5.5mm ace mesh wings, and 2mm ace mesh bag. Seining effort was maintained equal for individual sampling areas. Two sein hauls through an area of approximately 200 m2 surface area were taken at each area. Sites were collected at approximately monthly intervals (June 9 - Nov. 11) during the 1981 sampling season and at approximately bi-monthly intervals (June 9 - Oct. 8) during the 1982 season.

Fishes collected were preserved in 10% buffered formalin solution with subsequent preservation in alcohol. All fish (except large specimens over 250 mm in length) were returned to the laboratory for identification.

Water Quality:

It is widely known that differences in water quality affect the distribution of fishes (Nikolsky 1963, Hendricks et al. 1980). For this reason four of the most common water quality parameters which are known to affect fish distribution in relatively undisturbed environments (Hendricks et al. 1980) were examined in this study to determine if differences existed between backwater and mainstem habitats. The parameters examined included turbidity, pH, dissolved oxygen, and temperature. Field determinations were made of each of these parameters at each sampling locality. Turbidity (in Jackson Turbidity Units) and pH were analyzed using a Hach model dr-el 2 spectrophotometer. Dissolved oxygen was measured using a Hach water analysis kit. Temperature was measured using a degrees Celcius thermometer.

Analysis of Fish Communities:

Individual sampling localities were lumped together (by date) based on similarities in physical habitat (ie. backwater or river mainstem). Backwaters contain little or no current flow, are located off the river mainstem, contain some aquatic macrophytes, and usually have some type of feeder creek entering them. The bottom is of silt or silt/clay composition. Mainstem margin sites have some current flow (in river current flows average 1200 m3/s and range from 969 m3/s-15,451 m3/s; ORSANCO 1981, ORSANCO 1982), contain little or no aquatic macrophytes, and have a bottom of sand or sand/fine cobble mixture. Grouping together of these two habitat types is further substantiated by similarities in species composition (among backwaters or margins) as analyzed by the Sorenson (1948) index. The Sorenson index is used here to illustrate the similarities in species composition between the backwater or mainstem habitats. The Sorenson index compares the number of species present in one sample, the number of species present in the other sample, and the number of species common to both samples. It is calculated as follows:

$$S = 2C/A+B$$

Where: A = the number of species present in one sample

B = the number of species present in the other sample

C = the number of species common to both samples

Values of the Sorenson index range between 0 and 1. High values indicate similarities in species composition, lower values indicate dissimilarities. Sorenson indices were calculated for species composition by date and averaged for both 1981 and 1982. Average similarity values were calculated for backwater areas, mainstem areas, and between backwater and mainstem areas and are presented in Table 1.

Much work in community ecology has been aimed at measuring the association between species (Nash 1950, Cole 1949, Cole 1957, Fager 1957, Hurlbert 1969, Reice 1981). The basic concept behing this is to avoid the subjective problems of deciding (1) what species should be grouped together as a community, and (2) where community boundaries should occur. The hope is to formalize in an objective manner the basic idea of community organization: that species tend to be associated in a nonrandom manner (Krebs 1978).

In order to determine the composition of groups of associated species (communities) in backwater or marginal habitats, the recurrent group analysis developed by Fager (1957) and used by Inger and Chin (1962), Fager and McGowan (1963), Fager and Longhurst (1968), and Greenfield and Johnson (1981), was used. This analysis provides information on those species which are consistently found together in a particular habitat. In this way, one can generate information on those species which form the community in either the backwater or mainstem marginal habitats. In this method a dichotomous index of relationship is calculated for every species pair. The

		A	B	C	D	E	F	G	H	I	J	K
A) Shawnee Marina	(41)	-	28	24	25	26	23	18	13	13	15	16
B) Ginat Run	(38)	0.71	-	20	28	27	21	17	14	15	14	13
C) White Oak Cr.	(26)	0.72	0.63	-	19	20	21	15	9	9	12	13
D) Franklin Run	(34)	0.67	0.78	0.63	-	27	19	18	14	13	14	13
E) Brush Creek	(33)	0.70	0.76	0.68	0.81	-	21	19	14	14	16	13
F) Eagle Creek	(26)	0.69	0.66	0.81	0.63	0.71	-	14	9	11	13	11
G) Brush Creek Is.	(21)	0.58	0.58	0.64	0.65	0.70	0.59	-	11	11	11	10
H) Manchester Is.	(16)	0.46	0.52	0.43	0.56	0.57	0.43	0.60	-	9	9	8
I) Below Greenup	(17)	0.45	0.54	0.42	0.51	0.56	0.51	0.58	0.55	-	10	9
J) Little Scioto	(18)	0.51	0.50	0.54	0.54	0.63	0.59	0.56	0.53	0.57	-	11
K) Shawnee Beach	(18)	0.54	0.46	0.59	0.50	0.51	0.50	0.51	0.47	0.51	0.61	-

Table 1 Sorenson Similarity Coefficients for Ohio River Localities Based on Combined Species Data for Young-of-the-Year Fishes from All Collection Dates. Values in upper half of matrix (whole numbers) are actual number of common species. Values in lower half of matrix are calculated Sorenson coefficients between localities. Values in parentheses are total number of species collected from each locality.

index calculates the geometric mean of the proportion of joint occurrences based on presence and absence, and applies a correction for sample size. The index, hereafter referred to as IA (Index of Affinity) is calculated as follows:

$$IA = \frac{J}{Na - Nb} \qquad \frac{1}{2\ Nb}$$

Where:

Na = the number of occurrences of species a

Nb = the number of occurrences of species b

J = the number of joint occurrences

Note - species are assigned to letters such that Na Nb

Pairwise values of IA were calculated for all species in backwater or mainstem habitats except those that occurred in only one or two collections following the methods of Greenfield and Johnson (1981).

Associations were considered significant when IA $\geq$ 0.50 following the methods of Fager and McGowan (1963) and Fager and Longhurst (1968). Their logic in selecting this value as the cut-off point was that they felt species should be found together in somewhat more than half their recorded occurrences if they are to be grouped together. The formation of recurrent groups was based on two rules: 1) that every species within a group must show affinity with all other members of the group, thus ensuring that every species in a group frequently co-occurs with every other member, these species are here deemed primary associates; 2) that the largest possible groups must be formed. Species that showed affinity with some, but not all, of the members of a group were listed as associates of the group (Fager and Longhurst 1968), here deemed secondary associates.

Differences in densities between individual species will be used to determine relative preference of that particular species for backwater or mainstem marginal habitats as nursery areas. It is an effort to quantify observable trends in abundance between the habitats. An analysis of this type has been used by Cooper et al. (1981) to determine nursery area preference by larval fishes between inshore and offshore areas of Lake Erie. Densities of individual species of young-of-the-year fishes were calculated for each sampling date on the basis of the number of young-of-the-year captured from total backwater or mainstem localities and the surface area of water seined, and expressed as numbers of young of the year per 100m2. Significant differences in mean densities of individual species in backwater and mainstem habitats were analyzed using a t-test (Dixon and Massey 1969) on log transformed data. Differences in mean densities were considered to be statistically significant at the alpha = 0.05 level, unless otherwise noted at the alpha = 0.01 level.

Relative frequencies were tabulated for individual species to determine those species consistently found in either backwater or mainstem habitats. Trends in the abundance (density) of the top fifteen species were analyzed to determine periods of maximum abundance. Total species collected from backwater or mainstem sites were tabulated to determine period of maximum species abundance. The top species in abundance were also tabulated for total collections, backwaters, and mainstems. Diversity (Shannon and Weaver 1949) was also calculated by date for both habitat types. Diversity provides information as to the number of species and the eveness with which those species are distributed. It is used in this case to determine if fluctuations occur in these factors over the course of the summer period.

Trophic Habits and Dietary Overlap:

In an effort to determine the feeding habits of some of the species and overall trophic structure of the young-of-the-year fish community, the dietary habits of the fourteen most abundant species from 1982 were examined. Species of young-of-the-year were examined over three dates from the 1982 sampling season (July 21 or Aug 3, Aug 26, and Oct 7) in an effort to determine dietary fluctuations over the course of the summer season as well as changes in the trophic structure of the community. Number of stomachs examined per date usually ranged between 10 and 20. Since young of the year fishes were generally small, more traditional methods of stomach removal could not be employed. In order to remove the digestive tract, fishes were sectioned in the pharyngeal region anterior to the gill arches, a second incision was made along the upper portion of the flank laterally to the body cavity, the posterior section of the intestine was then seized with forceps and the whole digestive tract removed. The portion of the stomach analyzed varied according to the individual species. In general the area analyzed consisted of the area from the pharynx to the first 180 degree bend in the intestine following the methods of Hoyt (1970), Kneib (1978), and George and Hadley (1979). However, in three species (ie. white bass, Morone chrysops; spotted bass, Micropterus punctulatus; and sauger, Stizostedion canadense) only the area of the stomach could be examined. In areas posterior to the stomach food material could not be identified and thus was not included in the analyses. Since subsequent analysis was concerned with relative volumes of food items, this method of stomach analysis was deemed acceptable. Items found in the stomach were identified to the lowest practical taxonomic level using Pennak (1978), Merrit and Cummins (1978), Needham and Needham (1975), Taft and Taft (1971), and Usinger (1956). Volumetric analysis was performed on individual stomach contents following methods suggested by Windell (1971). Since food volumes of individual stomachs of young of the year fishes were relatively small, direct measurement by volumetric means was usually impossible. In this instance a mm grid was employed to estimate volume following Windell (ibid). Materials were removed from the fishes digestive tract, placed on a mm grid and piled to a uniform height. Volumes were then estimated based on the height and the number of mm squares the material occupied on the grid. Real volume estimates were performed on those items from stomach analysis above approximately 20 mm3 with the aid of a .5 cc tuberculin syringe or in the case of larger food items (above .5 cc) a 10 ml graduated cylinder was employed. Volume estimates were then converted to average of volume percentages for use in discussion and analysis of diet overlap between species.

The subject of food resource partitioning among adult freshwater fishes has been examined by a number of authors. Examples include works by Starret (1950), Zarret and Rand (1971), Moyle (1973), Mendelson (1975), Gascon and Leggett (1977), and Werner (1977). Comparatively little information has been published on resource partitioning or dietary habits of young-of-the-year fishes (Pflieger 1966, Buldley et al. 1976, Glenn 1978, George and Hadley 1979). Since young-of-the-year are limited in the size ranges of food available to them, it seems probable that competition between species may be highly important in those areas where they occur together. Pflieger (1966) suggested that competition between smallmouth bass fry and young-of-the-year of other fish species might be intense for this reason. The shallow water habitats of the Ohio River should provide an excellent area to examine this problem. In order to determine diet overlap among those species of young of the year examined, the Schoener (1970) diet-overlap index was employed. Wallace (1981), in an assessment of diet-overlap indices, recommended the use of the Schoener index based on the average of volume percentages over those used by Fritz (1974), George and Hadley (1979), Horn (1966), and Levins (1968). Use of the Schoener index is especially recommended where resource availability data is absent (Hurlbert 1978, Wallace 1981) as was the case in this study. The Schoener index gives values from 0 (indicating no diet overlap) to 1 (indicating complete diet overlap). It is calculated as follows:

$$D = 1 - .5 \text{ SUM } X1 - \text{SUM } X2$$

Where:

D = the amount of diet overlap

X1 = the proportion of food item X in species 1

X2 = proportion of food item X in species 2

Overlap was considered to be biologically significant when the overlap value exceeds 0.60 following the methods of Zarret and Rand (1971) and Mathur (1977).

Growth Rates of Selected Species:

The growth rates of those species used in the diet overlap study were also examined. The objective of this particular portion of the study is to provide information as to what species grow fastest and as to how this data compares with that reported for other areas. The objective provides information which is of potential importance in species interactions (ie. one species may grow faster than another which may alleviate a competitive interaction by moving on to another trophic level). This information is of interest to fisheries professionals concerned with management of the Ohio River, especially in terms of the growth rates of minnow species and gizzard shad (forage). Size of these species may be critical in determining the release of game fish fingerlings. Release of a fingerling into a system where the majority of forage has grown past a point of consumability (or in other words became too large) could have potentially disastrous effects on management efforts. Growth rates are also important as indicators of the quality of a particular habitat. The quality of an environment should be expressed in the diversity and types of food available which should reflect in an organisms growth rate. Therefore, the growth rates of the same species will be examined in other areas to get an idea of how the Ohio River compares with other areas. Measurements were performed using dial calipers with measurement to nearest 0.1 mm. Measurements were performed for all areas by date and averages plotted graphically. Between period growth rate was computed to determine periods of maximum growth.

RESULTS

Water Quality - see Table 2:

Backwater habitats averaged slightly warmer (1.2-2.3 °C) temperatures during initial periods examined (24 June 1981; 9 June, 24 June, and 7 July 1982). After these periods water temperatures stabilized between the two habitats and only small differences existed. Temperatures in backwaters varied between 11 and 30.5 °C. Mainstem margin temperatures varied between 13 and 29 °C.

Values of pH varied very little between backwater and mainstem marginal habitats. Differences in pH ranged from 0.09 to 0.51. Actual pH values ranged from 7.08 to 8.48 for backwaters and from 7.04 to 8.48 for mainstem margins.

Turbidity values averaged slightly higher in backwaters (from 6 to 32 Jackson Turbidity Units) during initial periods sampled (24 June, 24 July, and 11 August, 1981; 9 June and 24 June 1982) but stabilized thereafter with only slight differences existing. Initially high turbidity may have been due to high spring and early summer runoff which occurred during each year. Turbidity values ranged from 10 to 200 Jackson Turbidity Units in backwaters and from 10 to 100 Jackson Turbidity Units in the mainstem margins.

Dissolved oxygen was initially higher in backwater samples (24 June and 24 July 1981; 24 June and 7 July 1982) but stabilized after these dates with no great differences between the two habitats. Dissolved oxygen values ranged between 6 and 15 mg/l in backwaters and from 7 to 12.5 mg/l in mainstem margins. A possible reason backwaters exhibited higher initial dissolved oxygen concentrations than mainstem margins, despite the average warmer temperatures during those dates may be due to algal production. This observation has been cited by Miller et al. (1981) as causing elevated dissolved oxygen concentrations in tributary backwaters of the Ohio River.

Table 2: Water quality data for backwaters and mainstem margins of the Ohio River for 1981 and 1982. Data presented are averages based on samples taken from individual backwater or mainstem localities.

DATE	176	206	224	237	261	316	161	177	189	203	216	239	252	281
Temperature:														
Backwaters:	26.8	27.9	24.7	26.9	22.3	12.0	24.2	26.1	28.5	-	-	27.8	26.0	25.8
Mainstems:	25.6	28.2	27.8	27.6	23.5	12.8	22.7	24.2	26.1	-	-	27.5	25.6	25.0
pH:														
Backwaters:	8.48	8.23	8.23	8.38	7.75	7.13	7.08	7.55	7.38	-	7.60	7.55	7.45	7.50
Mainstems:	8.08	8.32	8.48	8.50	7.75	7.05	7.20	7.04	7.16	-	7.50	7.45	7.26	7.60
Turbidity:														
Backwaters:	76.3	66.8	58.7	44.5	28.0	15.0	117	60	29.2	-	36.7	24.2	35.8	8.3
Mainstems:	70.0	36.8	26.0	52.4	27.3	16.7	130	28.7	27.0	-	36.0	35.0	31.0	10.0
Dissolved Oxygen:														
Backwaters:	11.0	12.5	8.8	9.8	7.0	8.0	8.8	12.8	10.5	-	9.3	8.5	8.8	10.5
Mainstems:	10.3	11.5	8.8	10.7	7.0	8.9	7.5	10.4	9.0	-	10.4	9.0	8.0	11.0

Analysis of Fish Communities:

I am defining two communities of young-of-the-year fishes on the Ohio River, the backwater and the mainstem margin. A community is defined by Krebs (1978) as any assemblage of populations of living organisms in a prescribed area or habitat. In the case of this Ohio River study the prescribed area is the backwater or mainstem margin and the population is those species of young-of-the-year which reside in those areas. Krebs (1978) states that two main ideas are involved in community definitions: First, the minimum property of a community is the presence together of several species in an area. Second, that collections of virtually the same groups of species recur in space and in time, which means that one can recognize a "community type" which has a relatively constant composition. By using the Fager (1957) index to categorize these communities (ie. backwater or mainstem margin), those species of young-of-the-year which consistently co-occur are found (Table 3). From this analysis there are two distinct fish communities found in the Ohio River, one associated with the mainstem margins and one associated with the backwater habitat. Only four species of young-of-the-year fishes were found to form primary associations in marginal habitats, and only one species formed a secondary association (see Table 3). The community formed is a cyprinid dominated community, with silver chub, emerald shiner, river shiner, and mimic shiner making up the constituents. Only the gizzard shad represented a non-cyprinid member. Backwaters on the other hand, had a more diverse community of young-of-the-year fishes associated with them. Eight species formed primary associations with each other in backwaters, and six formed secondary associations (see Table 3). The community contains not only cyprinids, namely silver chub, emerald shiner, river shiner, mimic shiner, bluntnose minnow, and bullhead minnow; but also gizzard shad, bluegill, longear sunfish, spotted bass, largemouth bass, white bass, golden redhorse, and freshwater drum.

Sixty-five species of young of the year fishes (eighty including adults) were

Table 3: Young-of-the-year Fish Communities from the Ohio River Resulting from Analysis of Recurrent Groups using Fagers (1968) Index of Affinity.

BACKWATERS:

Primary associations:

Dorosoma cepedianum

Hybopsis storeriana

Notropis atherinoides

Notropis volucellus

Pimephales notatus

Pimephales vigilax

Lepomis macrochirus

Aplodinotus grunniens

Secondary associations:

Notropis blennius

Morone chrysops

Lepomis megalotis

Micropterus punctulatus

Micropterus salmoides

Moxostoma erythrurum

MARGINS:

Primary associations:

Dorosoma cepedianum

Notropis atherinoides

Notropis blennius

Notropis volucellus

Secondary associations:

Hybopsis storeriana

collected from all localities (Table 4). Fifty-four were collected from backwater localities, forty-two from mainstem margins. Only the following four species: Notropis atherinoides, Dorosoma cepedianum, Notropis volucellus, and Notropis blennius were collected in abundances above 100 for the entire sampling period (1981 and 1982) in mainstem marginal areas. N. atherinoides was collected in mainstem margins most (52408 specimens or 95.8% relative abundance of total number of individuals from total mainstem samples), followed by D. cepedianum (788 specimens, 1.4% rel. abund.), N. volucellus (702 specimens, 1.3% rel. abund.), and N. blennius (486 specimens, 0.9% rel. abund.). The top ten species in abundance for mainstem margins are listed in Table 5. Six species (Table 6) had high relative frequencies of occurrence (above 60%) indicating they were present in marginal habitats most of the summer period although not always in high numbers. The remaining species were collected at infrequent intervals (all below 40%) and in very low numbers.

Sixteen species were collected in abundances above 100 from backwater habitats over the 1981 and 1982 sampling periods (see Table 7). Dorosoma cepedianum dominated backwater samples (24145 specimens or 53.7% of total backwater young-of-the-year collected), followed by Notropis atherinoides (10356 specimens, 23.0% relative abundance), Notropis volucellus (2228 specimens, 4.9% rel. abund.), Lepomis macrochirus (1797 specimens, 4.0% rel. abund.), and Hybopsis storeriana (1320 specimens, 2.9% rel. abund.). Twenty-one species (Table 8) had relative frequencies above 60% in the backwater habitats, indicating prescence through most of the summer season. Remaining species were collected in 50% or less of backwater samples.

Significant differences among densities of individual species as analyzed by the t-test of backwater and margin localities are summarized in Table 9. Results indicate backwaters have significantly higher differences in density for twenty-two species than margins, which had no species present in significantly higher densities. Species exhibiting significant differences at the alpha = 0.01 level include all of the following:

Table 4: Distribution of Sixty-five Species of Young-of-the-Year Fishes in Backwater (BW) and Mainstem (MR) Margin Habitats of the Middle Ohio River

Species	BW	MR
Lepososteus osseus	8	2
Hiodon tergisus	0	12
Alosa chrysochloris	40	53
Dorosoma cepedianum	24145	788
Campostoma anomalum	19	4
Cyprinus carpio	2	2
Ericymba buccata	10	0
Hybopsis aestivalis	0	1
Hybopsis storeriana	1320	67
Hybopsis x-punctata	0	2
Nocomis micropogon	0	1
Notemigonus chrysoleucas	4	0
Notropis atherinoides	10356	52408
Notropis blennius	848	486
Notropis buchanani	248	2
Notropis chrysocephalus	7	0
Notropis spilopterus	97	1
Notropis stramineus	18	1
Notropis volucellus	2228	702
Notropis whipplei	10	1
Phenacobius mirabilus	9	3
Pimephales notatus	963	5
Pimephales vigilax	562	2
Rhinichthys atratulus	1	0
Semotilus atromaculatus	4	0
Carpiodes carpio	212	6
Carpiodes cyprinus	41	2
Carpiodes velifer	1	0
Catostomis commersoni	1	0
Hypentelium nigricans	10	1
Ictiobus bubalus	0	1
Ictiobus cyprinellus	1	0
Minytrema melanops	2	0
Moxostoma anisurum	4	0
Moxostoma duquesnei	5	0
Moxostoma erythrurum	101	1
Moxostoma macrolepidotum	13	0
Ictalurus punctatus	83	7
Pylodictus olivaris	0	1
Percopsis omiscomaycus	1	0
Labidesthes sicculus	41	3
Fundulus diaphanus	35	0
Fundulus notatus	1	0
Gambusia affinis	1	0
Morone chrysops	235	40

Table 4: Continued:

Ambloplites rupestris	1	0
Lepomis gibbosus	6	0
Lepomis gulosus	2	0
Lepomis humilis	2	0
Lepomis macrochirus	1797	5
Lepomis megalotis	191	1
Micropterus dolomieui	0	5
Micropterus punctulatus	128	46
Micropterus salmoides	69	13
Pomoxis annularis	87	0
Pomoxis nigromaculatus	20	0
Ammocrypta pellucida	0	1
Etheostoma blennioides	4	0
Etheostoma caeruleum	17	0
Etheostoma nigrum	2	0
Etheostoma zonale	0	1
Percina caprodes	29	4
Percina sciera	6	10
Stizostedion canadense	156	2
Aplodinotus grunniens	767	24

Table 5: Top species in abundance of young-of-the-year fishes from the Ohio River in mainstem margins: 1981 and 1982 combined.

	SPECIES	NO. YOY	REL. ABUND.
1)	*Notropis atherinoides*	52408	95.80
2)	*Dorosoma cepedianum*	788	1.4
3)	*Notropis volucellus*	702	1.3
4)	*Notropis blennius*	486	1.0
5)	*Hybopsis storeriana*	67	0.1
6)	*Alosa chrysochloris*	53	0.1
7)	*Micropterus punctulatus*	46	0.1
8)	*Morone chrysops*	40	0.1
9)	*Aplodinotus grunniens*	24	0.04
10)	*Micropterus salmoides*	13	0.02

Table 6: Those Species of Young-of-the-Year Fishes from Mainstem Marginal Habitats of the Middle Ohio River with Relative Frequencies above 60%

SPECIES	REL. FREQ (%)
Dorosoma cepedianum	92
Hybopsis storeriana	77
Notropis atherinoides	85
Notropis blennius	77
Notropis volucellus	77
Micropterus punctulatus	62

TABLE 7: Top species in abundance of young-of-the-year fishes from the Ohio River in backwater habitats: 1981 and 1982 combined.

	SPECIES	NO. YOY	REL. ABUND.
1)	*Dorosoma cepedianum*	24145	53.70
2)	*Notropis atherinoides*	10356	23.03
3)	*Notropis volucellus*	2228	4.90
4)	*Lepomis macrochirus*	1797	4.00
5)	*Hybopsis storeriana*	1320	2.90
6)	*Pimephales notatus*	963	2.10
7)	*Notropis blennius*	848	1.90
8)	*Aplodinotus grunniens*	767	1.70
9)	*Pimephales vigilax*	562	1.20
10)	*Notropis buchanani*	248	0.60
11)	*Morone chrysops*	235	0.55
12)	*Carpiodes carpio*	212	0.47
13)	*Lepomis megalotus*	191	0.43
14)	*Stizostedion canadense*	156	0.35
15)	*Micropterus punctulatus*	128	0.28
16)	*Moxostoma erythrurum*	101	0.22
17)	*Notropis spilopterus*	97	0.22
18)	*Pomoxis annularis*	87	0.19
19)	*Ictalurus punctatus*	83	0.18
20)	*Micropterus salmoides*	69	0.15

Table 8: Those Species of Young-of-the-Year Fishes from Backwater Habitats of the Middle Ohio River with Relative Frequencies above 60%.

SPECIES	REL. FREQ (%)
Dorosoma cepedianum	100
Campostoma anomalum	60
Hybopsis storeriana	79
Notropis atherinoides	100
Notropis blennius	71
Notropis spilopterus	60
Pimephales notatus	86
Pimephales vigilas	79
Carpiodes carpio	60
Moxostoma erythrurum	93
Ictalurus punctatus	64
Morone chrysops	86
Lepomis macrochirus	86
Lepomis megalotis	71
Micropterus punctulatus	93
Micropterus salmoides	79
Pomoxis annularis	86
Percina caprodes	86
Stizostedion canadense	86
Aplodinotus grunniens	79

Table 9: Young-of-the-year Fishes Exhibiting Significantly Higher Backwater Densities from the Ohio River based on the T-test. Differences are considered significant at the 0.05 level (df = 25). Calculations are based on log transformed data from densities per 100 m2.

SPECIES	T VALUE	LEV. OF SIG.
1) Dorosoma cepedianum	3.45	0.01
2) Hybopsis storeriana	3.43	0.01
3) Notropis spilopterus	3.03	0.01
4) Pimephales notatus	4.87	0.01
5) Pimephales vigilax	4.94	0.01
6) Carpiodes carpio	1.83	0.03
7) Moxostoma erythrurum	5.54	0.01
8) Ictalurus punctatus	2.34	0.03
9) Morone chrysops	1.92	0.05
10) Lepomis macrochirus	5.12	0.01
11) Lepomis megalotis	4.11	0.01
12) Micropterus punctulatus	2.29	0.03
13) Micropterus salmoides	2.23	0.03
14) Pomoxis annularis	4.61	0.01
15) Pomoxis nigromaculatus	1.82	0.05
16) Labidesthes sicculus	2.47	0.01
17) Stizostedion canadense	2.38	0.03
18) Percina caprodes	4.41	0.01
19) Aplodinotus grunniens	3.29	0.01

Dorosoma cepedianum, Hybopsis storereana, Notropis spilopterus, Pimephales notatus, Pimephales vigilax, Moxostoma erythrurum, Labidesthes sicculus, Lepomis macrochirus, Lepomis megalotis, Pomoxis annularis, Percina caprodes, and Aplodinotus grunniens. Ictalurus punctatus, Micropterus punctulatus, Micropterus salmoides, and Stizostedion canadense exhibited significantly higher abundances at the 0.025 level. Carpiodes carpio, Morone chrysops, and Pomoxis nigromaculatus exhibited differences at the 0.05 level. Significant differences in density between backwater and margins were not found for Notropis atherinoides, Notropis volucellus, and Notropis blennius.

A significant difference between total density (all species) of young-of-the-year fishes of backwater and mainstem margins was not found in this study. Maximum total density occurred on 3 August for both backwaters and margins in 1981, and on 21 July for backwaters and 3 August for margins in 1982 (Figures 2 and 3). Maximum number of species occurred on 24 July, 24 August, and 11 November, 1981 (N = 28) and on 26 August, 1982 (N = 35) for backwaters (Figure 4). Maximum number of species for margins occurred on 24 August, 1981 (N = 18) and 8 September, 1982 (N = 18, Figure 5).

Shannon-Weaver (1949) diversity was also highest in the backwater areas. Diversity was higher for averaged backwaters samples for all dates than margins (Table 10). Highest diversity for backwaters occurred on 24 August in 1981 (H' = 3.81) and 25 June in 1982 (H' = 2.69). Diversity values ranged between 2.12 and 3.81 for backwaters. Highest marginal diversity occured on 24 June, 1981 (H' = 2.39) and 8 September (H' = 0.82). All diversity values except the 24 June 1981 value were under 1.00. Marginal diversity values ranged from 0.17 to 2.39.

Community Dynamics:

It is important to realize that fluctuations did occur in community structure, especially in young-of-the-year fishes. The Fager (1957) analysis does not take into

Figure 2. Total number of young-of-the-year species collected from Ohio River backwaters and mainstem margins

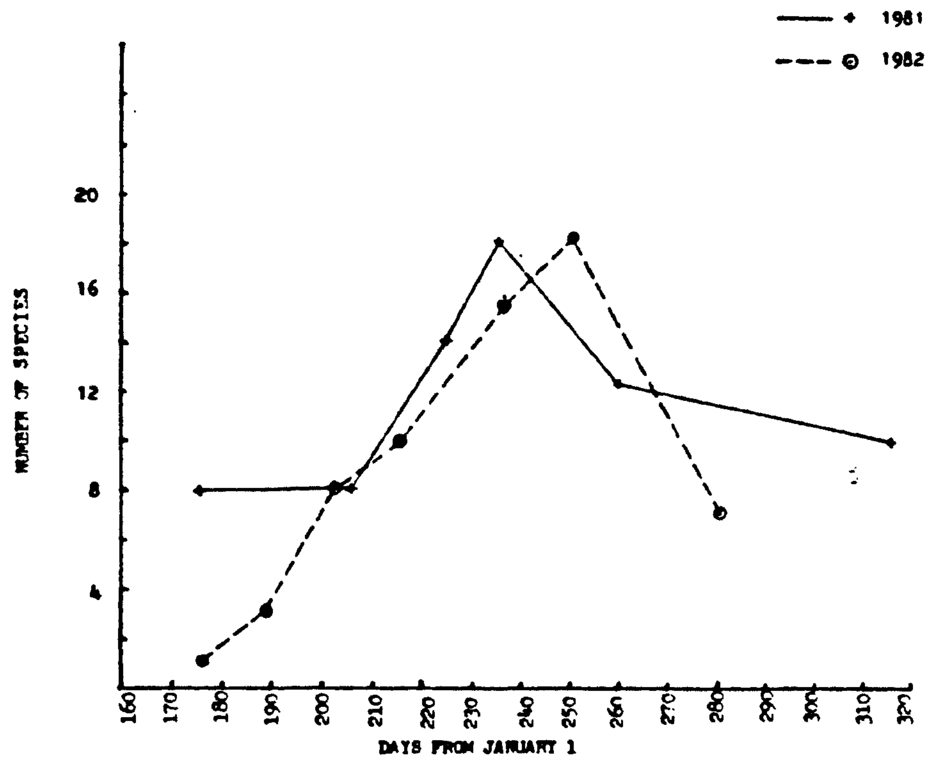


FIGURE 2A: Total Number of Species Collected - Mainstem Margins

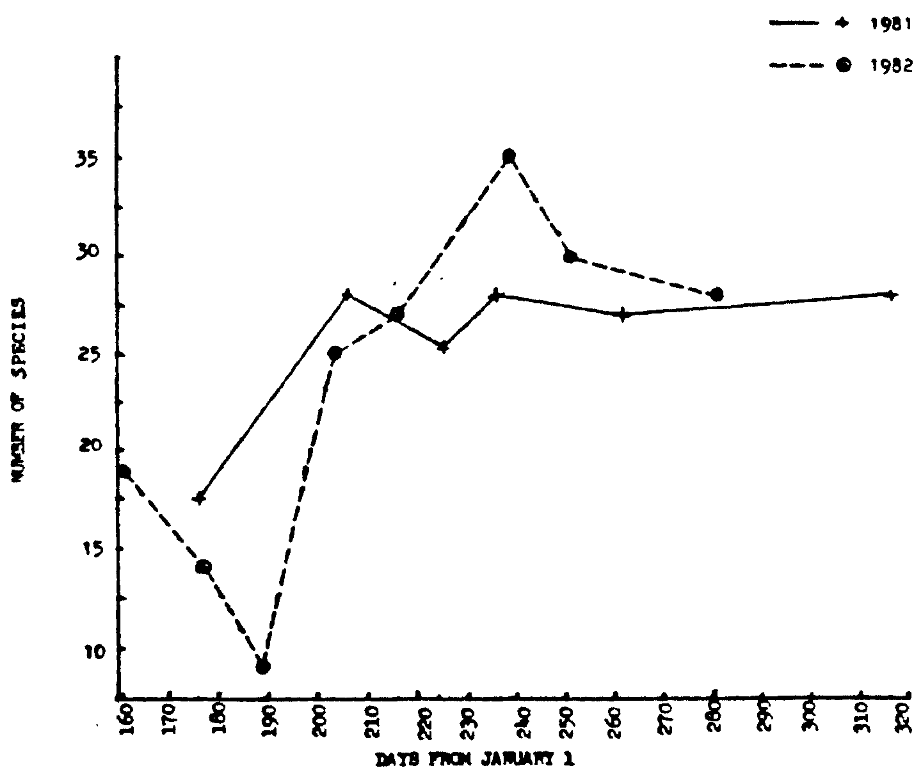


FIGURE 2B Total Number of Species Collected - Backwaters account those species which may temporarily occur and which may utilize a particular area for an important portion of their life cycle.

The fluctuations in abundance which occur may be largely due to differences in spawning time as well as behavioral differences. Fluctuations of this type have been thought to be mechanisms to reduce competition (Nikolsky 1969). What is seen in the backwater habitats of the Ohio River is a general transition from two species which occur very early relative to other species, white bass (Morone chrysops) and sauger (Stizostedion canadense), to the cyprinid species (silver chub - H. storeriana, emerald shiner - Notropis atherinoides, river shiner - Notropis blennius, mimic shiner - Notropis volucellus, bluntnose minnow - Pimephales notatus, and bullhead minnow - Pimephales vigilax), as well as gizzard shad - Dorosoma cepedianum, bluegill - Lepomis macrochirus, longear sunfish - Lepomis megalotis, spotted bass - Micropterus punctulatus, largemouth bass - Micropterus salmoides, golden redhorse - Moxostoma erythrurum, and drum - Aplodinotus grunniens. White bass and Sauger are only present in relatively high densities during June and early July samples. These species do not therefore show up in Fager's index of affinity since they do not consistently occur in the habitats. They none-the-less make up a substantial portion of the young-of-the-year fish community during the early part of the summer season. During this time they consume primarily plankton, converting to a primarily piscivorous diet after this time (see Dietary Habits section). It is assumed that after this date these fishes move primarily into the river mainstem. This idea is partially substantiated in the white bass from 1982 samples, where initially high densities in backwaters dropped with a corresponding increase in mainstem marginal densities during the later portion of the summer season. The movement of Sauger into the main river system is not as clearcut. Sauger densities in backwaters drop drastically following June samples, but mainstem margin densities never increased afterwords, with only two collections even containing young-of-the-year. Movements of sauger from tributarys to the river mainstem have been reported by Nelson (1968) to occur in Lewis and Clark Lake, an impounded Missouri River impoundment. It seems probable that this may also occur in the Ohio River, and it is felt that different sampling techniques used in deeper sections of the river may have yielded results which support this.

The majority of fishes which make up the stable community in backwater habitats appear in late July (24 July 1981 and 21 July 1982). Gizzard shad, emerald shiner, and bluegill (1981 only) did appear earlier however only a few specimens were present. The periods of maximum abundance of individual species does appear to fluctuate between the species and these fluctuations were relatively constant for both 1981 and 1982. In a relative sense, gizzard shad, silver chub, spotted bass, largemouth bass, and freshwater drum all generally reached maximum abundance earlier than other species, with maximum abundance occurring between 24 July and 11 August, 1981 (an exception occurred in the spotted bass which did not reach maximum abundance untill 17 September, however spotted bass were present in relatively high densities all through August), and between 7 July and 3 August 1982. Those species in which the maximum abundance occurred intermediately relative to other members of the community include bluntnose minnow, river carpsucker, and golden redhorse. Maximum abundance for these species occurred from 11 August to 24 August in 1981, and from 26 August to 8 September in 1982. Those species in which the maximum abundance occurred relatively late include emerald shiner, river shiner, mimic shiner, bullhead minnow, and longear sunfish. Maximum abundance of these species occurred on 11 November 1981, and from 26 August to 7 October, 1982.

A general transition in species abundance was also noticed in the mainstem marginal habitat, although only five species are found there consistently (gizzard shad, silver chub, emerald shiner, mimic shiner, and river shiner). In three of the species, gizzard shad, emerald shiner, and river shiner, the peak abundance occurred relatively early to the other species (using the same relative system of rating as presented in backwaters, ie. very early, early, intermediately, or late). The period of maximum abundance for these species occurred during 24 July and 11 August 1981, and 3 August 1982. The silver chubs maximum abundance occurred intermediately relative to the other species present during 24 August 1981 and 8 September 1982. The mimic shiner represented the only species which had a period of maximum abundance which could be considered relatively late. Maximum abundance occurred on 17 September 1981 and 8 September 1982. White bass, although not a part of the community proper as analyzed by the Fager (1957) index, does exhibit peak abundance in margins at an intermediate time (26 August 1982) relative to other species. As mentioned previously, it occurs relatively very early in the backwater habitat. This probably represents a transition of this species from backwaters to the mainstem which represents a more open water zone more condusive to this species relatively pelagic lifestyle.

It is interesting to note that the periods of maximum abundance for three of the species in the mainstem margin does not coincide with periods of maximum abundance in the backwater. Those species include silver chub, emerald shiner, and river shiner. Silver chub, in which maximum abundance occurred intermediately in the mainstem, occurred early in backwaters. Maximum abundance of both emerald shiner and river shiner occurred relatively early in the mainstem margin, and occurred relatively late in the backwater. Whether these differences represent something of biological significance is difficult to assess. The backwaters warm faster than mainstem margins (see Water Quality section) providing an opportunity for a species to spawn earlier. This may be a reason why silver chub are found earlier in backwaters than mainstem margins. However, this explanation provides no insight into the trends which occur in the emerald shiner and river shiner. Two explanations may be correct: 1) that these species prefer to spawn in open water and that once spawned the young-of-the-year hatch, reside in the mainstem for a period, and then move into the backwater; or 2) that individual populations of both species in backwaters and mainstem margins spawn at different times, creating different periods of maximum abundance for a particular species. Smith (1979) reports that spawning in emerald shiners is communal with fertilized eggs being broadcast over a substrate of mixed sand, gravel, and silt. Although no documentation of spawning habits of the river shiner has ever been reported, Smith (1979) speculates that spawning is likely communal over a sand and gravel substrate. It seems probable that both species could conceivably spawn in the mainstem margins, since this type of spawning habitat abounds there. The majority of young-of-the-year emerald shiners do first appear in the mainstem margins, with a corresponding lagging increase in backwaters. This does not occur in river shiner, however, which consistently exhibited higher backwater densities with no real lag in increasing (or decreasing) abundance.

Dietary Habits:

The objective of this particular portion of the analysis was to determine the kinds of food items the major species of young-of-the-year fishes in shallow water habitats were feeding upon and to use this information to determine trophic overlap among the species. Results of dietary habit analysis are presented for the fourteen most abundant species from the Ohio River for 1982 for individual dates and for pooled data (Tables 10-14). A discussion of the dietary habits of the fourteen individual species is presented as follows.

Dorosoma cepedianum - (see Table 15 for summary of the dietary habits of young-of-the-year gizzard shad): Young of the year gizzard shad stomachs in the Ohio River were found to contain almost exclusively bottom sediments. Pooled dietary data for the gizzard shad indicates 96.9% (mean volume per all stomach examined) of its' diet consisted of bottom sediments. The only other item in the diet was Cladocera (3.1%). This indicates young of the year were primarily benthic feeders during the periods they were examined in this study. Bottom sediments as defined here consisted of a greenish--

Table 10: Pooled Dietary Habits of Young-of-the-Year Fishes from the Ohio River for the Period between 21 July and 7 October. Data presented represents the average of volume percentages from individual stomachs. Abbreviations for species names are as follows: DCE = Dorosoma cepedianum, HST = Hybopsis storeriana, NAT = Notropis atherinoides, NBL = Notropis blennius, NVO = Notropis volucellus, PNO = Pimephales notatus, PVI = Pimephales vigilax, CPO = Carpiodes carpio, MCH = Morone chrysops, LMA = Lepomis macrochirus, LME = Lepomis megalotis, MPU = Micropterus punctulatus, SCA = Stizostedion canadense, AGR = Aplodinotus grunniens.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
Cladocera	3.1	0.2	82.8	0.2	9.0	1.1	1.0		1.9	29.6	1.1			1.2
Rotifera			4.9	0.7	10.5									
Bottom Ooze	96.9	10.2			55.9	61.0	24.8							
Copepoda		5.8	0.1	13.7	15.3	0.1	22.9	0.5		31.7	0.5			3.8
Chir. Adult					3.3									
Chir. Larvae		63.6	0.2	15.4	3.6	31.8	45.1		9.0	26.5	88.1	3.7		90.4
Fil.Grn.Alg.			11.1	53.5	1.9	3.1								
Bry. Stat.		0.2			0.1		1.2							
Adult Dipt.		8.0	0.5	0.9	0.5	3.0	3.31					0.1		0.1
Fish Larvae				4.2					82.3			84.3	100	2.0
Corixidae		8.9		2.9					5.4	11.2		5.1		1.5
Argulus									1.3	0.8				
Odonata Lar.				1.7							5.0	6.9		
Cil. Protozoa		0.1												
Trichop.Lar.		3.11	0.5	5.9										0.9
Shelled Proto.								99.5						
Ants				0.8										
Ostracoda					0.1									
Amphipoda											1.0			0.1
Ad. Coleop.											0.5			0.1
Coleop.Lar.										0.3				
Oligochaeta							1.7							
Ephem.Lar.											3.3			
Gastropoda											0.5			

Table 11: Dietary Habits of Young-of-the-Year Fishes from the Ohio River for 21 July. Data presented represents the average of volume percentages from individual stomachs. Abbreviations for species names are as follows: DCE = *Dorosoma cepedianum*, HST = *Hybopsis storeriana*, NAT = *Notropis atherinoides*, NBL = *Notropis blennius*, NVO = *Notropis volucellus*, PNO = *Pimephales notatus*, PVI = *Pimephales vigilax*, CPO = *Carpiodes carpio*, MCH = *Morone chrysops*, LMA = *Lepomis macrochirus*, LME = *Lepomis megalotis*, MPU = *Micropterus punctulatus*, SCA = *Stizostedion canadense*, AGR = *Aplodinotus grunniens*.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
Cladocera	1.1	0.5	99.9		3.8	3.5	1.3		3.7	50.9				0.8
Rotifera					17.9									
Bottom Ooze	98.9	5.8			13.5	9.1	29.2							
Copepoda		15.8	0.1	34.8	46.0		21.2	0.8		0.3				1.5
Chir. Adult					10.0									
Chir. Larvae		72.2		26.9	8.8	76.9	38.3		19.1	44.8	100	0.5		92.9
Fil.Grn.Alg.				16.0		1.1								
Bry. Stat.		0.7												
Ad. Diptera		5.0				9.4	9.9					0.1		
Fish Larvae				7.5					63.0			57.5	100	4.8
Corixidae				3.6					11.5	3.9		17.7		
Argulus									2.8					
Odonata Lar.				3.4								24.2		
Cil. Protozoa		0.1												
Trichop. Lar.				7.8										
Shel. Protozoa								99.2						

Table 12: Dietary Habits of Young-of-the-Year Fishes from the Ohio River for 26 August. Data presented represents the average of volume percentages from individual stomachs. Abbreviations for species names are as follows: DCE = Dorosoma cepedianum, HST = Hybopsis storeriana, NAT = Notropis atherinoides, NBL = Notropis blennius, NVO = Notropis volucellus, PNO = Pimephales notatus, PVI = Pimephales vigilax, CPO = Carpiodes carpio, MCH = Morone chrysops, LMA = Lepomis macrochirus, LME = Lepomis megalotis, MPU = Micropterus punctulatus, SCA = Stizostedion canadense, AGR = Aplodinotus grunniens.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
Cladocera	8.3		90.1		5.1		1.3		0.4	22.3	0.9			0.1
Rotifera			9.6	2.1	0.5									
Bottom Ooze	91.7	13.9			85.1	73.9	8.3							
Copepoda		0.7	0.3	6.4		0.1	35.6	0.8		24.7				4.3
Chir. Larvae		66.1		14.4	2.2	19.8	53.7			26.9	89.8			92.8
Fil.Grn.Alg.				57.0	5.8	6.2								
Bry. Stat.					0.1		1.1							
Ad. Diptera		16.8		2.7	1.4									
Fish									99.6			100	100	
Corixidae		2.5		5.1						26.1				
Odonata Lar.				1.7							2.5			
Trichop. Lar.				8.2										3.0
Shld. Protozoa								99.2						
Ants				2.3										
Ostracoda						0.1								
Ephem.Larvae											5.5			
Gastropoda											1.2			

Table 13: Dietary Habits of Young-of-the-Year Fishes from the Ohio River for 7 October. Data presented represents the average of volume percentages from individual stomachs. Abbreviations for species names are as follows: DCE = *Dorosoma cepedianum*, HST = *Hybopsis storeriana*, NAT = *Notropis atherinoides*, NBL = *Notropis blennius*, NVO = *Notropis volucellus*, PNO = *Pimephales notatus*, PVI = *Pimephales vigilax*, CPO = *Carpiodes carpio*, MCH = *Morone chrysops*, LMA = *Lepomis macrochirus*, LME = *Lepomis megalotis*, MPU = *Micropterus punctulatus*, SCA = *Stizostedion canadense*, AGR = *Aplodinotus grunniens*.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
Cladocera			58.2	0.7	18.5		0.3		0.4	15.5	1.1			3.0
Rotifera			5.0		12.9									
Bottom Ooze	100	10.9			69.1	98.5	36.8							
Copepoda	0.9						11.9			70.0	1.1			6.6
Chir. Larvae		52.5	0.1	5.0			43.4			7.8	81.6	10.0		84.5
Fil.Grn.Alg.			33.1	87.6		1.5								
Bry. Stat.							2.4							
Ad. Diptera		2.2	2.0											
Fish				5.0					99.6			90.0	100	
Corixidae		24.1								3.6				5.0
Argulus										2.2				
Odonata Lar.											9.4			
Trichop. Lar.		9.3	1.4	1.7										0.4
Shld. Protozoa								100						
Amphipoda											2.5			0.5
Ad. Coleop.											1.2			0.1
Coleop.Lar.										0.8				
Oligochaeta							5.2							
Ephem. Lar.											2.5			

Table 14: Dietary Habits of those early occurring Young-of-the-Year Fishes from the Ohio River. Data presented represents the average of volume percentages from individual stomachs. Abbreviations for species names are as follows: MCH = Morone chrysops, MPU = Micropterus punctulatus, SCA = Stizostedion canadense.

SPECIES	MCH	9 JUNE 1982 MPU	SCA
Cladocera	15.7	4.4	
Copepoda	15.2	22.6	
Bottom Ooze	10.0		
Chir. Larvae	35.9	0.6	32.3
Ad. Diptera		11.4	0.5
Fish Larvae	16.1	61.1	61.5
Trichop. Lar.	7.1		5.7

SPECIES	MCH	24 JUNE 1982 MPU	SCA
Cladocera	53.7		
Copepoda		11.5	
Chir. Larvae	3.9	0.5	0.5
Ad. Diptera		6.2	0.8
Fish Larvae	37.0	74.3	98.7
Ephem. Lar.		1.5	
Tabanidae		3.7	
Amphipoda	5.4		

SPECIES	MCH	7 JULY 1982 MPU	SCA
Cladocera	2.2		
Copepoda		0.4	
Chir. Larvae	0.2	0.4	0.2
Ad. Diptera		1.1	0.4
Fish Larvae	97.3	87.6	99.4
Argulus	0.3		
Ephem. Lar.		3.0	
Tabanidae		7.4	

Table 15: Dietary habits of gizzard shad (Dorosoma cepedianum) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 20	N = 20	N = 20	
Food item:				
Cladocera	1.1 (3)	8.3 (2)	-	3.1
Bottom ooze	98.9 (10)	91.6 (10)	100 (10)	96.9

gray heavy flocculent material which had no identifiable "living" material (ie. algae, diatoms) distributed in it. It is presumed the gizzard shad was digesting the organic portion of the sedimentery material and passing inorganic portions in a manner similar to that found by Pierce et al. (1981) in Acton Lake, a small Ohio reservoir. Diet remained relatively constant through the three periods examined. Mean volumes of organic matter varied from 98.9 to 91.7 to 100 percent of the total diet during the 21 July, 26 August, and 7 October dates.

The data presented here varies somewhat from that presented by other authors for young-of-the-year gizzard shad. Previous studies indicate that gizzard shad less than 35 mm total length feed primarily on microcrustaceans (Warner 1940, Kutkuhn 1958, Cramer and Marzolf 1970). Young above 35 mm, juveniles, and adults have been found to feed on phytoplankton, mollusc, insect larvae, and bottom sediments (Tiffany 1921, Ewers and Boesel 1936, Baker and Schmitz 1971, Jude 1973, King et al. 1977, Pierce et al. 1981). Gizzard shad examined here on 21 July averaged 23.3 mm total length, well below the 35 mm length established for microcrustacean feeding in young gizzard shad. It is apparent that young of the year gizzard shad in the Ohio River must convert from microcrustaceans at a much earlier stage (if at all) than that reported by other authors.

Table 16: Dietary habits of silver chub (Hybopsis storeriana) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 20	N = 20	N = 20	
Food item:				
Cladocera	0.5 (3)	-	-	0.2
Bottom ooze	5.8 (1)	13.9 (2)	10.9 (4)	10.2
Copepoda	15.8 (6)	0.7 (2)	0.9 (2)	5.8
Chironimdae Larv.	72.1 (10)	66.1 (10)	52.5 (9)	63.6
Bryozoan Stat.	0.7 (3)	-	-	0.2
Adult Diptera	5.0 (1)	16.8 (4)	2.2 (2)	8.0
Corixidae	3.6 (2)	2.5 (1)	24.1 (5)	8.9
Trichoptera Larv.	-	-	9.3 (3)	3.1

Hybopsis storeriana - (see Table 16 for summary of the dietary habits of young-of-the-year silver chub): Young-of-the-year silver chub in the Ohio River were found to feed primarily on benthic associated food items. Silver chub pooled dietary data consisted of 76.9% benthic material. Among those benthic items found, Chironomidae larvae was the primary item (63.6% mean volume), followed by bottom sediments (10.2%), and Trichoptera larvae (3.1%). However, some items considered more pelagic were also found, including Corixidae (backswimmer) adults (8.9%), adult diptera (8.0%), Copepoda (5.8%), Bryozoan statoblast (0.2%), and Cladocera (0.2%). Dietary habits varied somewhat over the three periods examined (21 July, 26 August, and 7 October). Chironomidae larvae represented the primary item on all three dates (72.2%, 66.1%, and 52.5% respectively), however it did drop in mean volume from period to period, which may have been the result of reduced abundance or decreased preference. Also mean volume of Copepoda dropped during the periods examined from 15.8 to 0.7 to 0.9%. Average volume of bottom sediments found in the diet increased after the 21 July date from 5.8% to 13.9% to 10.9%.

Little information is available concerning the diet of the silver chub, although one fairly complete study has been completed. Kinney (1954) found that young-of-the-year fed principally on Copepoda (39.5% by volume of total diet), Cladocera (10.9%), Chironomidae larvae and pupae (34.7%), and Trichoptera larvae (4.6%). Adults were found to feed primarily on Ephemeroptera naiads (66.7%), Sphaeriidae (9.6%), Gastropoda (7.7%), Cladocera (5.2%), and Chironomidae larvae (2.0%). Based on this data it appears that young-of-the-year silver chub in the Ohio River utilize more benthic items (ie. Chironomidae larvae, Trichoptera larvae, and bottom sediments) in their diet compared to Lake Erie individuals.

Notropis atherinoides: (see Table 17 for summary of the dietary habits of young-of-the-year emerald shiner) Young-of-the-year emerald shiners from the Ohio River were found to feed primarily on zooplankton. Pooled dietary data indicated that young-of-the-year emerald shiner fed primarily on Cladocera (82.8%), followed by filamentous green algae (11.1), Rotifera (Keratella sp. - 4.9%), adult Diptera (0.5%), Trichoptera larvae (0.5%), Chironomidae larvae (0.1%), and Copepoda (0.1%). Dietary habits varied somewhat during the three dates examined. Emerald shiners were found to change from a diet of almost exclusively zooplankton to one which included not only zooplankton,but also a great deal of filamentous green algae. During 21 July Cladocera comprised virtually all (99.99%) of the emerald shiner's diet (Copepoda = 0.01% of remaining total). Cladocera made up 90.1% of the diet on 26 August, with Rotifera second (9.6%),

Table 17: Dietary habits of emerald shiner (<u>Notropis atherinoides</u>) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 20	N = 20	N = 20	
Food item:				
Cladocera	99.9 (20)	90.1 (20)	58.2 (18)	82.8
Rotifera	-	9.6 (14)	5.0 (11)	4.9
Copepoda	0.1 (1)	0.3 (6)	-	0.1
Chironimdae Larv.	-	-	0.1 (1)	0.1
Fil. Green Algae	-	-	33.1 (10)	11.1
Adult Diptera	-	-	2.0 (1)	0.5
Trichoptera Larv.	-	-	1.4 (1)	0.5

and Copepoda the remaining 0.3%. The 7 Oct. date yielded the most variability in diet. Cladocera again comprised the majority of the diet (58.2%), followed by filamentous green algae (33.1%), Rotifera (5.0%), adult Diptera (2.0%), Trichoptera larvae (1.4%), and Chironomidae larvae (0.1%).

Previous literature indicates similar dietary habits for emerald shiners. Scott and Crossman (1973), Gray (1942), and Fuchs (1967) report adult feeding primarily on Cladocera, green algae, midge larvae, and Copepoda. Fuchs (ibid) found that blue-green algae and ciliated protozoa made up the emerald shiners diet up to the 25 mm (1") stage. Afterwords green algae was consumed in addition to these items. This varied from the results in this study, where zooplankton maintained an important role in the diet over all periods with green algae only important during the last date examined (7

October), when emerald shiners averaged 52.7 mm total length (Average total length for the three periods examined here were 28.7 mm, 44.5 mm, and 52.7 mm respectively). This increase in mean volumes of algae could be due to actual increase in the environmental abundance of algae or to increase food preference of algae. Lack of data on resource abundance makes a positive evaluation difficult.

Table 18: Dietary habits of river shiner (Notropis blennius) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 20	N = 20	N = 20	
Food item:				
Cladocera	-	-	0.7 (1)	0.2
Rotifera	-	2.1 (1)	-	0.7
Copepoda	34.8 (8)	6.4 (3)	-	13.7
Chironimdae Larv.	26.9 (4)	14.4 (9)	5.0 (1)	15.4
Fil. Green Algae	16.0 (7)	57.0 (17)	87.6 (18)	53.6
Adult Diptera	-	2.7 (2)	-	0.9
Larval Fish	7.5 (3)	-	5.0 (1)	4.2
Corixidae	3.6 (2)	5.1 (2)	-	2.9
Odonata Larvae	3.4 (1)	1.7 (1)	-	1.7
Trichoptera Larv.	7.8 (3)	8.2 (3)	1.7 (1)	5.9
Ants	-	2.4 (1)	-	0.8

Notropis blennius: (see Table 18 for summary of the dietary habits of young-of-the-year river shiner) Young of the year river shiners in the Ohio River consumed a wide variety of food items. Pooled dietary data indicates filamentous green algae comprised the majority of the diet (53.6%), followed by Chironomidae larvae (15.4%), Copepoda (13.7%), Trichoptera larvae (5.9%), larval fish (4.2%), Corixidae adults (2.9%), Odonata larvae (1.7%), adult Diptera (0.9%), ants (0.8%), Rotifera (0.7%), and Cladocera (0.24%). The river shiner's diet changed from one of primarily zooplankton and insect larvae to one of primarily filamentous green algae over the three dates examined. On 21 July Copepoda were the most important element in their diet comprising 34.8% of the average volume per stomach of those specimens examined. Chironomidae was second in volume (26.9%), followed by filamentous green algae (16.0), Trichoptera larvae (7.8%), larval fish (7.5%), Corixidae (3.6%), and Odonata larvae (3.4%). Filamentous green algae became the most utilized food item for the 26 August date (57.0%), followed by Chironomidae larvae (14.4%), Trichoptera larvae (8.2%), Copepoda (6.4%), Corixidae (5.1%), adult Diptera (2.7%), ants (2.4%), Rotifera (2.1%), and Odonata larvae (1.7%). Filamentous green algae was again the most important food item in the river shiner's diet in the 7 October date, comprising 87.6% of the total relative volume of items consumed. Chironomidae larvae (5.0%), larval fish (5.0%), Trichoptera larvae (1.7%), and Cladocera (0.7%) comprised the remaing portion of the diet.

Few detailed studies have been made on the biology of N. blennius, Smith (1979) refers to the biology of this species as "virtually unknown". This probably represents one of the first attempts to describe it's feeding habits. The data indicates an increasing importance of filamentous green algae over the course of the summer period. Whether this indicates an actual preference for this item with increasing size or increased feeding due to increased item availability is not known. Filamentous green algae was also found to increase in the diet of the emerald shiner (N. atherinoides) which suggest increased item availabilty. There was also a corresponding decrease in utilization of Copepoda in the river shiner's diet. The percentage consumed dropped from 34.8% to 6.38% to 0% over the three dates examined. Copepoda remained relatively high in the diet of those fishes which utilized them over the summer (Lepomis macrochirus, Pimephales vigilax, and Aplodinotus grunniens), which suggest a decreased preference for this item as this species grows, rather than a decrease in availability. Chironomidae larvae decreased from 26.9% of the relative volume on 21 July to 14.4% on 26 August to 5.0% on 7 October. As with Copepoda, Chironomidae larvae remained relatively stable in the diet of several of the other species examined (Hybopsis storeriana, Pimephales vigilax, Aplodinotus grunniens) through the summer period again suggesting a decrease in preference for this food item with age.

Notropis volucellus: (see Table 19 for feeding summary of young-of-the-year mimic shiner) Young-of-the-year mimic shiner in the Ohio River fed primarily on bottom sediments with zooplankton comprising most of the remaining portion of the diet. Pooled dietary data contained the following dietary groups: Organic matter (55.8%), Copepoda (15.3%), Rotifera (10.5%), Cladocera (9.0%), Chironomidae larvae (3.6%), adult Diptera (3.8%), filamentous green algae (1.9%), and Bryozoan statoblast and Ostracods(0.1%). Diet of the mimic shiner changed over the periods examined from primarily zooplankton to bottom sediments. Mimic shiners utilized copepods most during the 21 July date (46.0%), followed by Rotifera (18.0%), organic matter (13.5%), adult Diptera (10.0%), Chironomidae larvae (8.8%), and Cladocera (3.8%). Organic matter dominated relative dietary volumes during 26 August (85.0%), followed by filamentous green algae (5.8%), Cladocera (5.1%), Chironomidae larvae (2.2%), adult Diptera (1.4%), Rotifera (0.5%), and Bryozoan statoblast (0.1%). Organic matter again was most important in terms of volume for the 7 October stomachs (69.1%), followed by Cladocera (18.1%), and Rotifera (12.9%).

Young-of-the-year mimic shiners did not significantly utilize bottom sediments until sometime after the 21 July date (16.5mm stage). Only 20% of those stomachs examined on 21 July contained organic matter, whereas 100% and 80% of those stomachs examined contained 60% or more by volume on the 26 August and 7 October dates respectively. Zooplankton (Copepoda, Cladocera, and Rotifera) appear to be most important in the early stages of the mimic shiners life, since these items were found in all stomachs examined and in high volumes relative to other items. These items were found in 80% and 100% of the stomachs examined on 26 August and 7 October respectively, however they were not found in anywhere near the volume of bottom sediments.

Table 19: Dietary habits of mimic shiner (Notropis volucellus) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 20	N = 20	N = 20	
Food item:				
Cladocera	3.8 (4)	5.1 (8)	18.1 (8)	8.9
Rotifera	18.0 (4)	0.5 (3)	12.9 (5)	10.5
Bottom Ooze	13.5 (2)	85.0 (10)	69.1 (8)	55.9
Copepoda	46.0 (5)	-	-	15.3
Chironimdae Larv.	8.8 (2)	2.2 (4)	-	3.6
Fil. Green Algae	-	5.8 (4)	-	1.9
Bryozoan Stat.	-	0.1 (1)	-	0.03
Adult Diptera	10.0 (1)	1.4 (1)	-	3.8

It is assumed here that the bottom sediments are being utilized as a food source, with the usable organic portion of the material being digested and undigestible portions passed as feces. The relatively high amounts of material present and high numbers of stomachs containing this item seems to support this idea. However there is a possibility this material could be the result of an attempt to inhale a benthic food item (eg. chironomids), in which case one would expect a large proportion of benthic organisms in the stomachs examined. This was not the case in this study, where 7% of those stomachs examined contained chironomid larvae, the only food item which could be considered benthic in the mimic shiners diet (Pennak, 1978).

The diet of mimic shiners found in the Ohio River does not differ appreciably from the diet of mimic shiners in other studies. Moyle (1973) found that it's food consisted primarily of Diptera larvae and pupae, Cladocera, small terrestrial insects, and Amphipoda. Black (1945) reported that in Indiana Lakes the mimic shiner feeds mostly on small crustaceans (especially Cladocera), insects (particularly Chironomidae) and some algae.

Table 20: Dietary habits of bluntnose minnow (Pimephales notatus) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 10	N = 10	N = 10	
Food item:				
Cladocera	3.5 (7)	0.1 (1)	-	1.2
Bottom ooze	9.1 (1)	74.0 (9)	98.5 (10)	61.0
Chironimdae Larv.	76.2 (10)	19.8 (4)	-	31.8
Fil. Green Algae	1.1 (3)	6.2 (5)	1.5 (3)	3.1
Adult Diptera	9.4 (1)	-	-	3.1

<u>Pimephales notatus</u>: (see Table 20 for feeding summary of young-of-the-year bluntnose minnow) Young-of-the-year bluntnose minnow were found to feed primarily on

benthic material in this study. Benthic material comprised 60.5% by volume of the pooled bluntnose minnow diet, followed by Chironomidae larvae (32.2%), adult Diptera (3.1%), filamentous green algae (2.9%), Cladocera (1.2%), and Copepoda (0.1%). Dietary habits changed over the three periods examined from a diet of primarily Chironomidae larvae to a diet of primarily benthic matter. Chironomid larvae made up most (76.2%), of the average volume consumed during 3 August, followed by adult Diptera (9.4%), organic matter (9.1%), Cladocera (3.5%), and filamentous green algae (1.1%). All stomachs examined contained Chironomids, 10% contained adult Diptera, 10% contained organic matter, 70% contained Cladocera, and 30% contained filamentous green algae. The 26 August stomachs yielded quite different results. Organic matter dominated the volume of material present in those specimens examined (74.0% relative volume), followed by Chironomidae larvae (19.8%), filamentous green algae (6.2%), and Copepoda (0.1%). Eighty-five percent of those stomachs examined contained organic matter, 35% contained Chironomidae larvae, 45% contained filamentous green algae, and 10% contained Copepoda. Organic matter again dominated the material consumed for the 7 October date, making up 98.5% of the relative volume, followed by filamentous green algae (1.5%). All stomachs examined contained high volumes (90%) of organic matter, 30% contained filamentous green algae.

Previous literature supports the findings of the dietary study on the feeding habits of the bluntnose minnow. Keast and Webb (1966), studying adults in Lake Opinicon, Ontario found that the food consumed consisted almost entirely of organic detritus (bottom ooze) from the bottom (20-50% by volume), chironomid larvae (5-30%), and Cladocera (10-75%). Their samples from Kearing Lake, Algonquin Park, indicate bluntnose minnows fed promarily on chironomid larvae and algae.

Pimephales vigilax: (see Table 21 for feeding summary of young-of-the-year bullhead minnow) The major element in the pooled diet of young-of-the-year bullhead minnow (Pimephales vigilax) was Chironomidae larvae (45.1%). Organic matter randed --

Table 21: Dietary habits of bullhead minnow (Pimephales notatus) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 10	N = 10	N = 10	
Food item:				
Cladocera	1.3 (3)	1.3 (2)	0.3 (2)	1.0
Bottom Ooze	29.2 (4)	8.3 (1)	36.8 (5)	24.8
Copepoda	21.2 (8)	35.6 (10)	11.9 (5)	22.9
Chironimdae Larv.	38.3 (6)	53.7 (8)	43.4 (7)	45.1
Ologochaeta	-	-	5.2	1.7
Adult Diptera	9.9 (1)	-	-	3.3

second (24.8%), followed by Copepoda (22.9%), adult Diptera (3.3%), Oligochaeta (1.7%), Bryozoan statoblast (1.2%), and Cladocera (1.0%). Some variability existed in proportion of items in the diet over the three dates examined, although chironomid larvae were consistently the most prevalent food by volume (38.3%, 53.8%, and 43.4% respectively; 70% of all stomachs examined). Organic matter was utilized most heavily during the 21 July and 7 October dates (40% and 50% respectively of all stomachs examined contained at least 35% organic matter by relative volume). Organic matter consisted of only 8.3% of total relative volume (10% of stomachs examined) on 26 August. Copepods were utilized most heavily during the first two periods examined (21 July = 21.2%, 26 Aug. = 35.6%; 100% of stomachs examined), and dropped bothe in relative volume (11.9%) and in percent occurence in stomachs (50%). The other items examined occurred sporadically in low relative volumes during the periods examined. Adult Diptera were fed upon during the 3 August date only (9.1% rel. vol.; 10% of stomachs examined). Aquatic Oligochaetes were found in the diet on the 7 October date (5.2% rel. vol.; 10% of stomachs examined). Bryozoan statoblast were utilized during the 26 August (1.1% rel. vol.) and 7 October (2.4% rel.vol.) dates and were present in 20% of the stomachs examined on each date. Cladocera, although present in stomachs on all dates examined, were present in low relateve volumes and in only 20 - 30% of the stomachs.

Dietary habits presented here seem to be in line with data presented by Starrett (1950), who reported that the bullhead minnow feeds on or near the bottom and it's diet consist mostly of insects (Chironomidae).

Table 22: Dietary habits of river carpsucker (Carpiodes carpio) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 0	N = 10	N = 10	
Food item:				
Shelled Protozoa		99.2 (10)	100 (10)	99.6
Copepoda	-	0.8 (2)	-	0.4

Carpiodes carpio: (see Table 22 for feeding summary of young-of-the-year river carpsucker) Only two food items were found in the diet of the river carpsucker (Carpiodes carpio). Minute protozoa dominated the diet of this species (occurring in 99.5% of the pooled dietary relative volumes), followed by Copepoda (0.5%). Young-of-the-year river carpsucker did not occur in our samples until 26 August and were therefore only examined for the 26 August and 7 October dates. On 26 August minute protozoa occupied 99.2% of the relative volume of materials consumed (100% of stomachs examined) and Copepoda occupied 0.8% (20% of stomachs). Only minute protozoa were found on the 7 October date (100% rel. vol.). Minute protozoa as found here consisted entirely of shelled members of the Sarcodina (Arcella, Euglypha, Diffugia).

Only one other dietary study has been conducted on the river carpsucker. Brezner (1958) studied the food habits of the river carpsucker in Lake of the Ozarks, Missouri and concluded that it fed from the bottom, browsing extensively on attached filamentous algae and consumeng large quantities of single-celled algae, protozoans, and small crustaceans associated with the attached algae. Additional items found included immature aquatic insects, aquatic worms, mollusks, and miscellaneous parts of higher plants. It appears from this analysis that the diet of the river carpsucker in Ohio is considerably more narrow. Brezners study concerned adult fishes so perhaps young-of-the-year are limited in the food items they can consume.

Morone chrysops: (see Table 23 for feeding summary of young-of-the-year white bass) Dietary habits of the white bass (Morone chrysops) was examined over five dates (9 June, 24 June, 7 July, 21 July, and 25 August; no specimens were collected on 7 October). Pooled dietary habits for all dates indicate fish (primarily Notropis atherinoides) as the most abundant food in terms of relative volume (62.6%). Fish were followed by Cladocera (15.1%), Chironomidae larvae (11.8%), Copepoda (3.0%), Corixidae (2.3%), organic material (2.0%), Trichoptera larvae (1.5%), Amphipoda (1.1%), and Argulus (0.6%). During the five dates examined there was a general transition in dietary habits from small crustaceans to fish. Those white bass examined on 9 June contained the following items: Chironomidae larvae (35.9% rel. vol, 80% of stomachs examined), larval fish (16.1% vol., 20% of stomachs examined), Cladocera (15.2% vol., 70% of stomachs examined), Copepoda (15.2% vol., 60% of stomachs examined), organic matter (10% vol., 10% of stomachs examined), and Trichoptera larvae (7.1% vol., 10% of stomachs examined). Cladocera became the primary item in those individuals examined

Table 23: Dietary habits of white bass (Morone chrysops) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	9 June	24 Jne	7 July	21 Jly	26 Aug	Pooled
# examined	10	10	10	10	10	
Food item:						
Cladocera	15.7	53.7	2.2	3.7	0.4	2.0
Chironimdae Larv.	35.9	3.9	0.2	-		9.0
Fish	16.1	37.0	97.3	63.0	99.6	82.3
Corixidae	-	-	-	11.5	-	5.4
Argulus	-	-	0.3	2.8	-	1.3
Trichoptera Larv.	7.1	-	-	-	-	5.9

on 24 June (53.7% vol., 86% of stomachs examined), followed by fish (37% vol., 43% of stomachs examined), Amphipoda (5.4% vol., 30% of stomachs examined), and Chironomidae larvae (3.9% vol., 30% of stomachs examined). On 7 July most of the stomach volumes consisted of fish (97.3% vol., 100% of stomachs examined), followed by Cladocera (2.2% vol., 23% of stomachs examined), Argulus (0.3% vol., 15% of stomachs examined), and Chironomidae larvae (0.2% vol., 15% of stomachs examined). Volume of fish dropped in the 21 July stomachs (63.0% vol., 70% of stomachs examined), with Chironomidae larvae (19.0% vol., 30% of stomachs examined), and a new item, Corixidae (backswimmers - 11.5% 20% of stomachs examined) increasing in volume. Cladocera (3.7% vol., 20% of stomachs examined) and Argulus (2.8% vol., 10% of stomachs examined) were also present. By 26 August, all specimens examined contained fish (99.6% vol.), followed by Cladocera (0.4% vol., 10% of stomachs examined).

Data presented here does not differ markedly from studies presented by other authors. Sigler (1949) found that small crustaceans and insects were most important in the diet of young white bass, with fish becoming present in larger volumes in stomachs as the species grows. Scott and Crossman (1973) report that younger, smaller fish feed on microscopic crustaceans, insect larvae, and fishes; with fishes (yellow perch) becoming increasingly important in the diet with an increase in size.

Table 24: Dietary habits of bluegill (Lepomis macrochirus) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 10	N = 10	N = 10	
Food item:				
Cladocera	50.9 (9)	22.3 (6)	15.5 (9)	29.6
Copepoda	0.3 (4)	24.7 (8)	70.0 (10)	31.7
Chironimdae Larv.	44.8 (6)	26.9 (5)	7.8 (4)	26.5
Argulus	-	-	2.3	0.8
Coleoptera Larvae	-	-	0.8	0.3

Lepomis macrochirus: (see Table 24 for feeding summary of young-of-the-year bluegill) Pooled dietary data for the bluegill (Lepomis macrochirus) indicates three items were of fairly equal importance in terms of volume. Copepoda comprised 31.7% of the average of volume percentage in those stomachs examined, followed closely by Cladocera (29.6%) and Chironomidae larvae (26.5%). Other items found include Corixidae (11.2%), Argulus (0.8%), and Coleoptera larvae (0.3%). Over the three periods examined (3 August, 26 August, and 7 October) the proportion of the afore-mentioned items in the diet changed somewhat. There was a general trend away from benthic dwelling Chironomidae larvae to more pelagic Copepoda and Cladocera (zooplankton). Chironomidae larvae dropped from 44.8% by volume (3 Aug., 60% of stomachs examined) to 26.9% (26 Aug., 50% of stomachs examined) to 7.8% (7 Oct., 40% of stomachs examined). Copepoda increased in proportion over the three dates from 0.3% (40% of stomachs examined) to 50.9% (80% of stomachs examined) to 70.0% (100% of stomachs examined). Cladocera dropped in percentage volume from 50.9% (90% of stomachs examined) to 22.3% (60% of stomachs examined) to 15.5% (90% of stomachs examined). Proportion of Corixidae, the only other item present in the diet over all three dates examined went from 3.9% (10% of stomachs examined) to 26.0% (40% of stomachs examined) to 3.6% (10% of stomachs examined). Argulus (2.3% rel. vol.,20% of stomachs examined) and Coleoptera larva (0.8% rel. vol., 10% of stomachs examined) occurred on the 7 October date only.

Dietary habits of the young of the year bluegills examined here varied little from that reported for primarily adults by other authors. Scott and Crossman (1973) report the food of the bluegill to be generally insects, crustaceans, and plant material. Keast and Webb (1966) found the major foods of the bluegill in Lake Opinicon (Canada) to be Chironomidae larvae (up to 50% of the food volume of any individual stomach), Cladocera (30%), Amphipoda and Isopoda (10%), flying insects (35%), Odonata naids (20%), Ephemeroptera naids (10%), Trichoptera larvae (15%), Mollusca (15%), and fish fry (10%). They report that only proportion and not composition varied with size and age. Pfleiger (1975) reports that bluegil fry feed primarily on small crustaceans. He also reported that adult bluegills feed at all levels with diet consisting of mayflies, insects, small fish, crayfish, snails, and vegetation (primarily algae; when animal food is scarce).

<u>Lepomis megalotis</u>: (see Table 25 for feeding summary of young-of-the-year longear sunfish) Pooled dietary data from the longear sunfish (<u>L. megalotis</u>) indicate the primary food consumed was Chironomidae larvae (90.5% rel vol., 100% of stomachs

Table 25: Dietary habits of longear sunfish (Lepomis megalotis) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	3 August	26 August	7 October	Pooled Av.
# examined	N = 10	N = 10	N = 10	
Food item:				
Cladocera	-	0.9 (2)	1.1 (3)	0.7
Copepoda	-	-	1.1 (2)	0.4
Chironimdae Larv.	100 (10)	89.8 (10)	81.6 (10)	90.5
Odonata Larvae	-	2.5 (1)	9.4 (2)	4.0
Amphipoda	-	-	2.5 (1)	0.8
Adult Coleoptera	-	-	1.2 (2)	0.4
Ephem. larv.	-	5.5 (2)	2.5 (1)	2.7
Gastropoda	-	1.3 (1)	-	0.4

examined). This was followed by Odonata larvae (4.0%), Ephemeroptera larvae (2.7%), Amphipoda (0.8%), Cladocera (0.7%), Gastropoda (0.4%), adult Coleoptera (0.4%), and Copepoda (0.4%). Only Chironomidae larvae were found in those stomachs examined on the 3 August date. On 26 August Chironomidae larvae comprised 89.8% (100% of stomachs examined) of the longear sunfish diet, followed by Ephemeroptera larvae (5.5% rel.vol., 20% of stomachs examined), Odonata larvae (2.5% rel. vol., 10% of stomachs examined), Gastropoda (1.3% rel. vol., 10% of stomachs examined), and Cladocera (0.9% 20% of stomachs examined). On 7 October Chironomidae larvae again were the major element in the longear sunfish diet (81.6% rel. vol., 100% of stomachs examined), followed by Odonata larvae (9.4%, 20% of stomachs examined), Ephemeroptera larvae

(2.5%, 10% of stomachs examined), Amphipoda (2.5%, 10% of stomachs examined), adult Coleoptera (1.2%, 20% of stomachs examined), Cladocera (1.1%, 30% of stomachs examined), and Copepoda (1.1%, 20% of stomachs examined).

It appears from the data that aquatic (mostly benthic) macroinvertebrates are the main constituent of the diet of young-of-the-year longear sunfish in the Ohio River. Zooplankton (Cladocera, Copepoda) also play a minor role in this species diet.

Little information is available on the dietary habits of young-of-the-year longear sunfish. Pflieger (1975) and Scott and Crossman (1973) report that adults feed on insect larvae, mature insects, and small crayfish.

Micropterus punctulatus: (see Table25Afor feeding summary of young-of-the-year spotted bass) Pooled dietary data for the spotted bass indicate fish to be the primary item in this species diet (79.3% rel. vol.), followed by Odonata larvae (4.8%), Copepoda (4.6%), Corixidae (3.5%), adult Diptera (2.5%), Chironomidae (2.3%), Tabanidae larvae (1.5%), Cladocera (0.9%), and Ephemeroptera larvae (0.6%). Composition and average of volume percentages of food items varied over the dates examined, although fish remained the most utilized item in the diet. Stomachs sampled on the 9 June date (ave. total length = 32.2 mm) yielded the following results: fish (61.1% rel. vol., 60% of stomachs examined), Copepoda (22.6%, 30% of stomachs examined), adult Diptera (11.4%, 20% of stomachs examined), Cladocera (4.4%, 10% of stomachs examined), and Chironomidae larvae (0.6%, 10% of stomachs examined). On 7 July fish compresed 87.6% of the relative volume of items found (100% of stomachs examined), followed by Tabanidae (7.4% rel. vol., 10% of stomachs examined), Ephemeroptera larvae (3.0%, 10% of stomachs examined), adult Diptera (1.1%, 10% of stomachs examined), Copepoda (0.4%, 10% of stomachs examined), and Chironomidae larvae (0.4%, 10% of stomachs examined). On 21 July fish again were the most utilized item (57.5% rel. vol., 63% of stomachs examined), followed by Odonata larvae (24.2%, 25% of stomachs examined), Corixidae (17.7%, 50% of stomachs examined), Chironomidae larvae (0.5%, 25% of ------

Table 25A: Dietary habits of spotted bass (Micropterus punctulatus) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	9 June	24 Jne	7 Jly	21 Jly	26 Aug	7 Oct.	Ave.
# examined							
Food item:							
Cladocera	-	-	0.7 (1)		0.2		
Rotifera	-	2.1 (1)		-	0.7		
Copepoda	34.8 (8)		6.4 (3)		-	13.7	
Chironimdae Larv.		26.9 (4)		14.4 (9)		5.0 (1)	15.4
Fil. Green Algae		16.0 (7)		57.0 (17)		87.6 (18)	53.6
Adult Diptera		-	2.7 (2)		-	0.9	
Larval Fish	7.5 (3)		-	5.0 (1)		4.2	
Corixidae	3.6 (2)		5.1 (2)		-	2.9	
Odonata Larvae		3.4 (1)		1.7 (1)		-	1.7
Trichoptera Larv.		7.8 (3)		8.2 (3)		1.7 (1)	5.9
Ants	-	2.4 (1)		-	0.8		

stomachs examined), and adult Diptera (0.1%, 10% of stomachs examined). Only fish were found in stomachs examined on 26 August. The 7 October date again found a high volume of fish (90.0%, 90% of stomachs examined) in the spotted bass diet, followed by Chironomidae larvae (10.0%, 10% of stomachs examined).

The data indicates fish as the most important food item throughout the dates examind. However, aquatic microcrustaceans (Copepoda, Cladocera), benthic macroinvertebrates (Chironomidae larvae, Odonata larvae, Tabanidae larvae, and

Ephemeroptera larvae), and adult Insecta (Corixidae, adult Diptera), appear to be important in the diet of the spotted bass during the early portion of the summer period (9 June - 21 July). Fish appear to dominate the diet as the species gets larger during the remainder of the summer period (26 August and 7 October).

Feeding habits of spotted bass in the Ohio River are somewhat similar to that reported by another author. Smith and Page (1969) found that aquatic insect larvae and small crustaceans were important in the diet of spotted bass less than 3 inches in length. Aquatic insect larvae, crayfish, and fish were the primary items found in larger bass.

Stizostedion canadense: (see Table 26 for feeding summary of young-of-the-year sauger) Pooled dietary data for the sauger (S. canadense) indicate fish larvae (10 - 15 mm total length) to be the most important item in the diet (86.7% rel. vol., 88% of stomachs examined), followed by Chironomidae larvae (11.0%), and adult Diptera (0.4%). Sauger diet on 9 June consisted of fish (61.5%, 70% of stomachs examined), followed by Chironomidae larvae (32.3%, 50% of stomachs examined), Trichoptera larvae (5.7%, 10% of stomachs examined). and adult Diptera (0.5%, 10% of stomachs examined). Diet of the sauger consisted of primarily fish larvae (98.7%, 100% of stomachs examined) by 24 June, with only a fraction of the relative volume percentages consisting of adult Diptera (0.8%, 15% of stomachs examined) and Chironomidae larvae (0.5%, 15% of stomachs examined). By 21 July, the diet of those saugers examined consisted entirely of fish (100%). Only two young-of-the-year saugers were collected after the 21 July date (one specimen each on 26 August and 8 September). Both stomachs contained only fish.

The data indicates saugers rely heavily on fish, with benthic aquatic macroinvertebrates (Chironomidae and Trichoptera larvae) important in the early stages of the saugers life (around the 41.4 mm total length stage). Past 55 mm, saugers fed mainly on fish.

Data from previous studies indicate similar food preferences for saugers in other

Table 26: Dietary habits of sauger (<u>Stizostedion canadense</u>) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 10	N = 10	N = 10	
Food item:				
Cladocera	-	-	0.7 (1)	0.2
Rotifera	-	2.1 (1)	-	0.7
Copepoda	34.8 (8)	6.4 (3)	-	13.7
Chironimdae Larv.	26.9 (4)	14.4 (9)	5.0 (1)	15.4
Fil. Green Algae	16.0 (7)	57.0 (17)	87.6 (18)	53.6
Adult Diptera	-	2.7 (2)	-	0.9
Larval Fish	7.5 (3)	-	5.0 (1)	4.2
Corixidae	3.6 (2)	5.1 (2)	-	2.9
Odonata Larvae	3.4 (1)	1.7 (1)	-	1.7
Trichoptera Larv.	7.8 (3)	8.2 (3)	1.7 (1)	5.9
Ants	-	2.4 (1)	-	0.8

areas. Scott and Crossman (1973) report that food changes from zooplankton to Chironomidae larvae to immature and adult Ephemeroptera with change in size of young-of-the-year. Priegel (1969) found that fry of other fishes were taken by sauger in the 12-50 mm size range.

<u>Aplodinotus grunniens</u>: (see Table 27 for feeding summary of young-of-the-year drum) Pooled dietary data indicates the freshwater drum (<u>A. grunniens</u>) fed primarily on Chironomidae larvae (90.4% rel. vol., 100% of stomachs examined), followed ------------

Table 27: Dietary habits of freshwater drum (Aplodinotus grunniens) young-of-the-year from the Ohio River. Diet is expressed as average of volume percentages of all stomachs examined. Number in parentheses is number of stomachs containing item.

Date:	21 July	26 August	7 October	Pooled Av.
# examined	N = 14	N = 10	N = 10	
Food item:				
Cladocera	0.8 (5)	0.1 (1)	3.0 (3)	1.2
Copepoda	1.5 (5)	4.3 (8)	6.6 (5)	3.8
Chironimdae Larv.	92.9 (14)	92.8 (10)	84.5 (10)	90.4
Adult Diptera	-	-	4.2	0.1
Larval Fish	4.8 (1)	-	-	2.0
Corixidae	-	-	5.0 (1)	1.5
Trichoptera Larv.	-	3.0 (2)	-	0.9
Amphipoda	-	-	0.5 (1)	0.2

by Copepoda (3.8%), fish larvae (2.0%), Corixidae (1.5%), Cladocera (1.2%), Trichoptera larvae (0.9%), Amphipoda (0.1%), adult Diptera (0.1%), and adult Coleoptera (0.1%). On 21 July, Chironomidae larvae made up 92.9% of the diet, followed by fish larvae (4.8%, 78% of stomachs examined), Copepoda (1.5%, 36% of stomachs examined), and Cladocera (0.8%, 36% of stomachs examined). During 26 August, Chironomidae larvae made up 92.8% of the average relative volume in those stomachs examined, followed by Copepoda (4.3%, 80% of stomachs examined), Trichoptera larvae (3.0%, 20% of stomachs examined), and Cladocera (0.1%, 10% of stomachs examined). Chironomidae larvae still dominated the diet in 7 October stomachs (84.5%), followed by Copepoda (6.6%, 50% of stomachs examined), Corixidae (5.0%, 10% of stomachs examined), Cladocera (3.0%, 30%

of stomachs examined), Amphipoda (0.5%, 10% of stomachs examined), Trichoptera larvae (0.4%, 10% of stomachs examined), and adult Coleoptera (0.1%, 10% of stomachs examined).

Chironomidae larvae appear to be the main element in the diet of young-of-the-year drum in the Ohio River, with zooplankton and aquatic macroinvertebrates also moderately important in the diet. This information is futher substantiated in reports by other authors. Scott and Crossman (1973), Daiber (1952), and Edsall (1967) all report that young-of-the-year drum consume primarily zooplankton and Chironomidae larvae.

Trophic Structure:

The various species of young-of-the-year fishes in the Ohio River occupy several positions on the trophic ladder. Some have a specialized diet, others are partially specialized, while others are omnivorous. Although some changes in the relative volume of a particular food item (ie. Cladocera, Rotifera) occurred in some species, the proportion of major type of item (ie. zooplankton, insecta) changed very little, with those changes which occurred being modified by seasonal changes and availability of foods. Therefore, to illustrate the trophic structure of the community of young-of-the-year fishes in backwater or marginal habitats, pooled data were utilized. Figure 3 represents the trophic structure of young-of-the-year fishes in backwater habitats. Those species which had a relatively speciealized diet included gizzard shad - primarily bottom ooze; river carpsucker - primarily shelled protozoans; emerald shiner - primarily zooplankton; drum - primarily benthic insects; longear sunfish - primarily benthic insects; silver chub - primarily insects; white bass - primarily fish; spotted bass - primarily fish; and sauger - primarily fish. The bluegill fed on a combination of insects and zooplankton. The bluegill fed on a combination of insects and zooplankton. Few species exhibited an omnivorous feeding mode. Those species included river shiner, mimic shiner, bluntnose

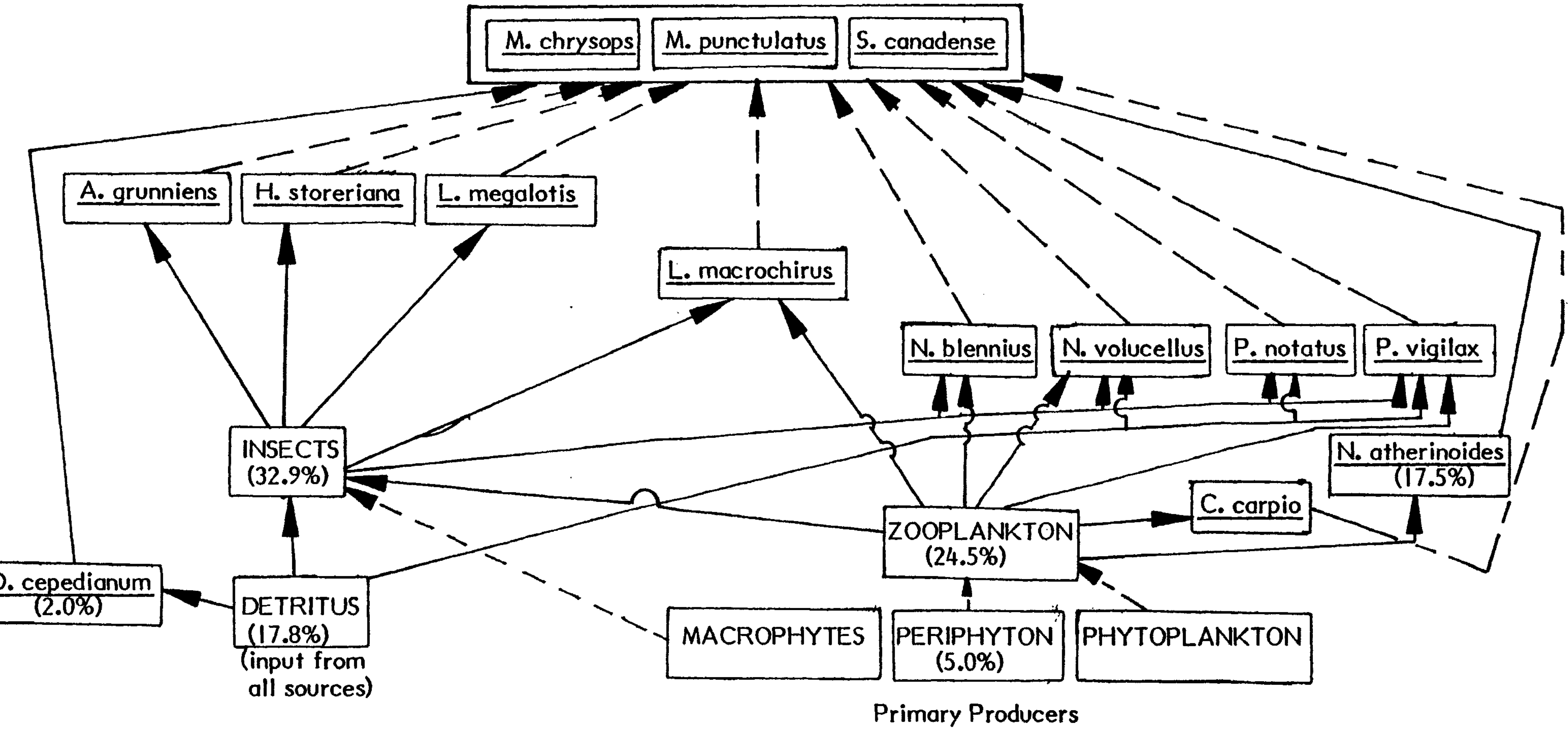


Figure 3: An Illustration of the Trophic Structure of Young-of-the-Year Fishes in Backwater Habitats of the Ohio River. Solid lines indicate observed relationships, dotted lines represent non-observed but probable relationships. Relative volume percent of food items consumed by all species is given in parentheses.

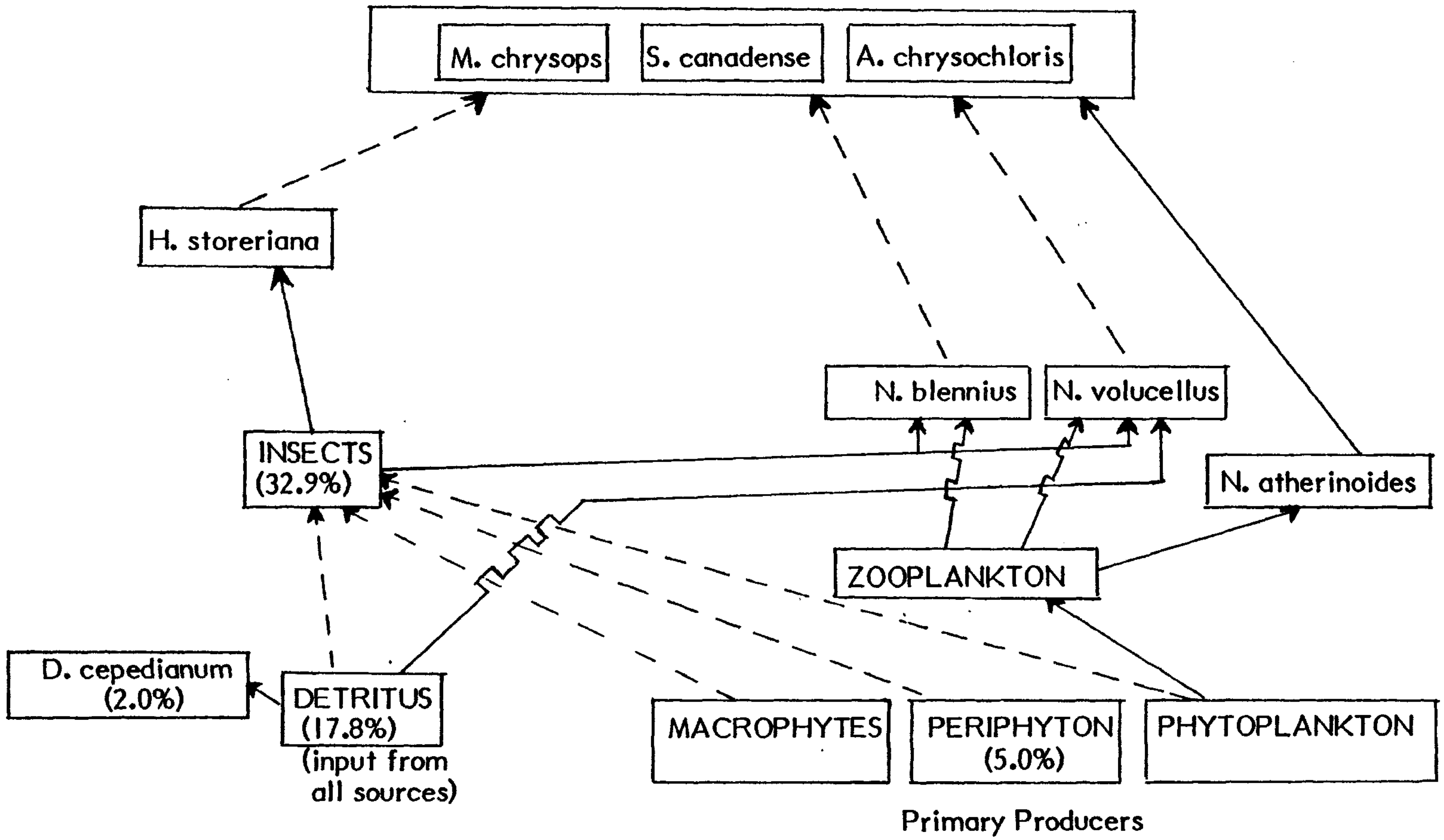


Figure 4: An illustration of the Trophic Structure of Young-of-the-Year Fishes in Mainstem Marginal Habitats of the Ohio River. Solid lines indicate observed relationships, dotted lines represent non-observed but probable relationships. Relative volume percent of food items consumed by all species is given in parentheses.

Table 28: Pooled Schoener Index of Dietary Overlap Values for Young-of-the-Year Fishes from the Ohio River for the Period between 21 July and 7 October. Abbreviations for species names are as follows: DCE = *Dorosoma cepedianum*, HST = *Hybopsis storeriana*, NAT = *Notropis atherinoides*, NBL = *Notropis blennius*, NVO = *Notropis volucellus*, PNO = *Pimephales notatus*, PVI = *Pimephales vigilax*, CPO = *Carpiodes carpio*, MCH = *Morone chrysops*, LMA = *Lepomis macrochirus*, LME = *Lepomis megalotis*, MPU = *Micropterus punctulatus*, SCA = *Stizostedion canadense*, AGR = *Aplodinotus grunniens*.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
DCE	-													
HST	0.10	-												
NAT	0.00	0.01	-											
NBL	0.00	0.28	0.14	-										
NVO	0.59	0.20	0.16	0.21	-									
PNO	0.62	0.46	0.05	0.19	0.63	-								
PVI	0.26	0.65	0.02	0.30	0.45	0.61	-							
CPO	0.00	0.01	0.01	0.01	0.01	0.01	0.01	-						
MCH	0.02	0.15	0.02	0.16	0.06	0.10	0.10	0.00	-					
LMA	0.03	0.41	0.30	0.32	0.28	0.28	0.50	0.01	0.33	-				
LME	0.01	0.64	0.01	0.18	0.05	0.33	0.47	0.01	0.10	0.28	-			
MPU	0.00	0.10	0.01	0.12	0.04	0.05	0.04	0.00	0.91	0.09	0.09	-		
SCA	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.82	0.00	0.00	0.84	-	
AGR	0.01	0.70	0.02	0.24	0.08	0.33	0.51	0.01	0.14	0.33	0.90	0.07	0.02	-

Table 29: Schoener Index of Dietary Overlap Values for Young-of-the-Year Fishes from the Ohio River for 21 July. Abbreviations for species names are as follows: DCE = Dorosoma cepedianum, HST = Hybopsis storeriana, NAT = Notropis atherinoides, NBL = Notropis blennius, NVO = Notropis volucellus, PNO = Pimephales notatus, PVI = Pimephales vigilax, CPO = Carpiodes carpio, MCH = Morone chrysops, LMA = Lepomis macrochirus, LME = Lepomis megalotis, MPU = Micropterus punctulatus, SCA = Stizostedion canadense, AGR = Aplodinotus grunniens.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
DCE	-													
HST	0.06	-												
NAT	0.01	0.01	-											
NBL	0.00	0.43	0.00	-										
NVO	0.14	0.31	0.04	0.44	-									
PNO	0.10	0.83	0.03	0.28	0.21	-								
PVI	0.30	0.65	0.01	0.48	0.49	0.58	-							
CPO	0.00	0.01	0.00	0.01	0.01	0.00	0.01	-						
MCH	0.01	0.20	0.04	0.30	0.12	0.23	0.20	0.00	-					
LMA	0.01	0.46	0.51	0.31	0.13	0.48	0.40	0.01	0.27	-				
LME	0.00	0.72	0.00	0.27	0.09	0.77	0.38	0.00	0.19	0.45	-			
MPU	0.00	0.01	0.00	0.15	0.01	0.01	0.01	0.01	0.69	0.04	0.01	-		
SCA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.57	-	
AGR	0.01	0.74	0.01	0.33	0.16	0.78	0.41	0.01	0.25	0.46	0.93	0.05	0.05	-

Table 30: Schoener Index of Dietary Overlap Values for Young-of-the-Year Fishes from the Ohio River for 26 August. Abbreviations for species names are as follows: DCE = *Dorosoma cepedianum*, HST = *Hybopsis storeriana*, NAT = *Notropis atherinoides*, NBL = *Notropis blennius*, NVO = *Notropis volucellus*, PNO = *Pimephales notatus*, PVI = *Pimephales vigilax*, CPO = *Carpiodes carpio*, MCH = *Morone chrysops*, LMA = *Lepomis macrochirus*, LME = *Lepomis megalotis*, MPU = *Micropterus punctulatus*, SCA = *Stizostedion canadense*, AGR = *Aplodinotus grunniens*.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
DCE	-													
HST	0.14	-												
NAT	0.08	0.01	-											
NBL	0.00	0.20	0.02	-										
NVO	0.90	0.17	0.06	0.10	-									
PNO	0.74	0.34	0.01	0.21	0.82	-								
PVI	0.10	0.63	0.02	0.21	0.12	0.28	-							
CPO	0.00	0.01	0.01	0.01	0.00	0.01	0.01	-						
MCH	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	-					
LMA	0.08	0.37	0.23	0.26	0.07	0.20	0.53	0.01	0.01	-				
LME	0.01	0.66	0.01	0.16	0.03	0.20	0.55	0.00	0.01	0.01	-			
MPU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	-		
SCA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	1.00	-	
AGR	0.01	0.67	0.01	0.22	0.02	0.20	0.58	0.01	0.01	0.31	0.90	0.00	0.00	-

Table 31: Schoener Index of Dietary Overlap Values for Young-of-the-Year Fishes from the Ohio River for 7 October. Abbreviations for species names are as follows: DCE = *Dorosoma cepedianum*, HST = *Hybopsis storeriana*, NAT = *Notropis atherinoides*, NBL = *Notropis blennius*, NVO = *Notropis volucellus*, PNO = *Pimephales notatus*, PVI = *Pimephales vigilax*, CPO = *Carpiodes carpio*, MCH = *Morone chrysops*, LMA = *Lepomis macrochirus*, LME = *Lepomis megalotis*, MPU = *Micropterus punctulatus*, SCA = *Stizostedion canadense*, AGR = *Aplodinotus grunniens*.

SPECIES	DCE	HST	NAT	NBL	NVO	PNO	PVI	CPO	MCH	LMA	LME	MPU	SCA	AGR
DCE	-													
HST	0.11	-												
NAT	0.00	0.03	-											
NBL	0.00	0.07	0.36	-										
NVO	0.69	0.11	0.23	0.01	-									
PNO	0.98	0.11	0.01	0.01	0.69	-								
PVI	0.37	0.58	0.03	0.08	0.37	0.37	-							
CPO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-						
MCH	0.00	0.00	0.01	0.05	0.01	0.00	0.01	0.00	-					
LMA	0.00	0.13	0.16	0.06	0.15	0.00	0.20	0.00	0.01	-				
LME	0.01	0.54	0.02	0.06	0.01	0.00	0.45	0.00	0.01	0.10	-			
MPU	0.00	0.10	0.01	0.10	0.00	0.00	0.10	0.00	0.90	0.08	0.10	-		
SCA	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.90	-	
AGR	0.00	0.60	0.04	0.06	0.03	0.00	0.50	0.00	0.01	0.21	0.85	0.10	0.00	-

minnow, and bullhead minnow. Each of these species consumed a variety of items including detritus (bottom ooze), insects, periphyton (filamentous green algae), and zooplankton.

Since only a few are considered to make up the community in mainstem margins, the trophic structure is not as diverse (see Figure 4) as that found in the backwater. Those species which had a specialized diet include gizzard shad - primarily bottom ooze; silver chub - primarily insects, and emerald shiner - primaily zooplankton. Those species which had an omnivorous feeding mode included river shiner and mimic shiner. Those species which specialized mainly on fish included white bass, sauger, and skipjack. Although these species of young-of-the-year do not show op consistently in the mainstem margin communiy, they represent those species which are the potential piscivores in this system.

Dietary Overlap:

Eleven species pairs exhibited significant dietary overlap (Schoener index value above 0.60 - Zarret and Rand 1971) using pooled dietary data (see Tables 28-31) from the 21 July (or 3 Aug.), 26 August, and 7 October dates. In general, overlap values remained high over all three periods examined in those eleven species pairs, although some variability exhisted. For this reason, species pairs which showed high dietary overlap (0.60) will be discussed individually.

By analyzing dietary overlap I am trying to determine the amount of competition which is taking place between two particular organisms for food. Using the generally used definition given by Krebs (1978): the situation which occurs when a number of organisms of the same or of different species utilize common resources that are in short supply - then it is difficult to analyze competition in this paper, since data on resource abundance is lacking from this study. However, an attempt can be made to analyze patterns of dietary overlap, which may indicate the potential for dietary competition should resources fall in short supply. Therefore, high dietary overlap values suggest potential competition for food, although such competition cannot be proven.

High dietary overlap values do not necessarily indicate one-to-one competition. Although two species may be utilizing the same food items, overlap may be reduced spatially, temporally, or behaviorally. So although two species feed on the same items, they may be feeding on them in different areas (bottom vs. vegetation), at different times (morning vs. night), or in differing manors of foraging behavior. However, if they are feeding on the same items, there is still potential for competition, should resources become limited, or as found by Zarret and Rand (1971) and Greenfield et al. (1983), increased trophic isolation in the event of limited resources.

Dorosoma cepedianum - Notropis volucellus: Significant dietary overlap between these two species occurred on the last two of the three dates examined. Diet-overlap was 0.16 on 21 July, 0.90 on 26 August, and 0.60 on 7 October. Gizzard shad (D. cepedianum) fed primarily on bottom ooze (91.7 - 100% ave. rel. vol.) with the remaining portion of the diet consisting of Cladocera. Diet of the mimic shiner (N. volucellus) varied more over the three dates examined, hence the variability in diet-overlap values between the two species. On 21 July, mimic shiners fed primarily on Copepoda (46.0%) and Rotifera (18.0%), with small portions of the diet consisting of organic matter (13.5%) and Cladocera (3.8%); compared to 98.9% relative volume of bottom ooze and 1.1% Cladocera for gizzard shad on the same date. Relative percent of organic matter increased tremendously in the diet of mimic shiners (85.0%) on the 26 August date, which was close to the relative volume consumed by gizzard shad (91.7%). Proportion of Cladocera increased in the diet of both species (8.3% for gizzard shad, 5.1% for mimic shiner). Similarities in proportion of these items led to the increase in the value of dietary overlap (Shoener index = 0.90). An increase in plankton (Cladocera = 18%, Rotifera = 12.9%) in the diet of the mimic shiner, coupled with a lack of Cladocera in the diet of the gizzard shad, led to the lower (although still significant) index of dietary overlap encountered on 7 October (Schoener index = 0.60), although both species still consumed high amounts of bottom ooze (mimic shiner = 69.1%, gizzard shad = 100%).

Hybopsis storeriana - Lepomis megalotis: Significant dietary overlap occurred between the silver chub (H. storeriana) and longear sunfish (L. megalotis). Dietary overlap as calculated from pooled data from these two species was 0.64 for the three dates examined. Dietary overlap was considered significant on two of the three dates examined. The Schoener index value on 21 July was 0.72 and on 26 August was 0.66. Overlap dropped below the significant level on 7 October (Schoener index = 0.54). Dietary overlap was due mainly to the high average relative volumes of Chironomidae larvae consumed by each species over all three dates examined. On 21 July the only common item in the diet was Chironomidae larvae which made up 72.2% of the mean relative volume of silver chub and 100% for longear sunfish. On 26 August, Chironomidae larvae again were the only common item found in the diet of these species (66.1% for silver chub, 89.8% for longear sunfish). On 7 October, Copepoda were consumed commonly in addition to Chironomidae larvae (0.9% for silver chub, 1.1% for longear sunfish), however Chironomidae larvae accounted for 97% of the overlap (52.5% mean rel. vol. for silver chub, 81.6% mean rel. vol. for longear sunfish).

Hybopsis storeriana - Aplodinotus grunniens: Significant dietary overlap occurred during all periods examined between silver chub (H. storeriana) and freshwater drum (A. grunniens). The Schoener index value for pooled data was 0.70. Overlap values varied from 0.74 on 21 July, to 0.67 on 26 August, to 0.60 on 7 October. Dietary overlap was due mainly to the high volumes of Chironomidae larvae consumed by each species over the periods examined. On 21 July, silver chub consumed 72.2% (mean relative volume percentage) Chironomidae versus 92.9% by drum. This food item accounted for 97.5% of the dietary overlap value. Other common items in the diet which were present in small quantities included Cladocera and Copepoda. On 26 August, silver chub diet consisted of

66.1% Chironomidae larvae and drum diet consisted of 92.8% Chironomidae larvae. This item again accounted for a high percentage (98.6) of the overlap. Copepoda was also a common item found in the diet of both species. On 7 October, four items were found common in the diet of these two species. Chironomidae larvae again accounted for a high percentage (89%) of the dietary overlap. Silver chub diet consisted of 52.5% Chironomidae larvae and drum diet consisted of 84.5% Chironomidae during 7 October. Other items found commonly in the diet included Copepoda (silver chub = 0.9%, drum = 6.6%), Corixidae (silver chub = 24.1%, drum = 5%), and Trichoptera larvae (silver chub = 9.3%, drum = 0.4%).

Notropis volucellus - Pimephales notatus: Dietary overlap was significant for pooled dietary data from mimic shiners (N. volucellus), and bluntnose minnows (P. notatus). The Schoener index value for pooled data was 0.63. Dietary overlap varied over the three periods examined. On the 21 July date (3 August was used in analysis for bluntnose minnow) the index of diet overlap value was 0.21. Low overlap was due to the high volumes of Copepoda (46%) and Rotifera (18%) in the diet of mimic shiners on this date in contrast to the high volumes of Chironomidae larvae consumed by bluntnose minnow. Overlap increased dramatically to 0.82 by 26 August, mainly due to the high relative volumes of bottom ooze present in the stomachs of the two species (mimic shiner = 85%, bluntnose minnow = 74%; 90% of overlap). Other items common in the diet on 26 August included filamentous green algae (mimic shiner = 5.8%, bluntnose minnow = 6.2%; 7.1% of overlap), and Chironomidae larvae (mimic shiner = 2.2%, bluntnose minnow = 19.8%; 2.9% of overlap). Dietary overlap was again significant on 7 October with a Schoener index value of 0.69. Overlap was entirely due to high volumes of bottom ooze present in the stomachs of each species (mimic shiner = 69.1%, bluntnose minnow = 98.5%).

The dietary overlap encountered here provides a good example of the dynamic aspects of the feeding habits (and consequent overlap) of young-of-the-year fishes. On examination of these species at an early stage in their lives (before 3 August in this case), the conclusion would be that overlap between the two species is low. However, as these species grow and shift position in the trophic hierchy, they begin to consume common food items and overlap becomes increasingly more significant.

Pimephales notatus - Pimephales vigilax: Dietary overlap was considered significant when considering pooled data from the three dates examined for these species. Dietary overlap from pooled data for the bluntnose minnow (P. notatus) and bullhead minnow (P. vigilax) was 0.61. Most of the dietary overlap was due to Chironomidae larvae (bluntnose minnow = 31.8%, bullhead minnow = 45.1%; 52% of overlap value) and bottom ooze (bluntnose minnow = 61%, bullhead minnow = 24.8%; 41% of overlap value). Other common items consumed included Cladocera (bluntnose minnow = 1.1%, bullhead minnow = 1.0%), Copepoda (bluntnose minnow = 0.1%, bullhead minnow = 22.9%), and adult Diptera (bluntnose minnow = 3%, bullhead minnow = 3.3%). Although dietary overlap calculated from pooled data was considered significant, overlap values from the three common dates examined were not. Overlap on 3 August was 0.58, on 26 August was 0.28, and on 7 October was 0.37. On 3 August, four food items were common to both species, including Chironomidae larvae (bluntnose minnow = 76.9%, bullhead minnow = 38.3%), bottom ooze (bluntnose minnow = 9.1%, bullhead minnow = 29.2%), adult Insecta (bluntnose minnow = 9.4%, bullhead minnow = 9.9%), and Cladocera (bluntnose minnow = 3.5%, bullhead minnow = 1.3%). Three food items were found common between the species on 26 August, although the amounts consumed by each species were not very similar. They included bottom ooze (bluntnose minnow=74%, bullhead minnow = 8.3%), Copepoda (bluntnose minnow = 0.1%, bullhead minnow = 35.6%), and Chironomidae larvae (bluntnose minnow = 19.8%, bullhead minnow = 53.8%). Only bottom ooze was found common to both species on 7 October (bluntnose minnow = 98.5%, bullhead minnow = 36.8%).

Pimephales notatus - Aplodinotus grunniens: Dietary overlap was found to be significant during one date of the periods examined between the bluntnose minnow and freshwater drum. The dietary overlap value from pooled data was low (Schoener index = 0.33). However, on 3 August a predominance of Chironomidae larvae in the diet of each of these two species (bluntnose minnow = 76.9%, drum = 92.9%; 98.6% of overlap value) led to a Schoener index value of 0.78. Also common in the diet was Cladocera (bluntnose minnow = 3.5%, drum = 0.8%). Shifting dietary preference of the bluntnose minnow with age (from primarily Chironomidae larvae to primarily organic matter), coupled with stable dietary preference of the drum for Chironomidae larvae, led to ever decreasing values of dietary overlap over the summer period (Schoener index = 0.20 for 26 August and 0.0 for 7 October).

Pimephales notatus - Lepomis megalotis: A temporary dietary interaction was found to exist between the bluntnose minnow and longear sunfish. As with the trophic interaction described previosly between the bluntnose minnow and freshwater drum, significant dietary overlap occurred on the 3 August date only and was due to a predominance of Chironomidae larvae in the diet of both species (bluntnose minnow = 76.9%, longear sunfish = 100%). Dietary overlap dropped significantly over the next two periods examined (Schoener index = 0.20 on 26 August and 0.0 on 7 October). Again, this was due to the dietary shift which occurred in the bluntnose minnow from Chironomidae larvae to bottom ooze and the relatively stable predominance of Chironomidae larvae in the diet of the longear sunfish.

Pimephales vigilax - Aplodinotus grunniens: A trophic interaction occurred on one of the three dates examined between the bullhead minnow and freshwater drum. Dietary overlap was close significant on 26 August when the overlap value was 0.58. Although not significant, it is deemed worthy of discussion based on its relatively high value. Overlap on 21 July was 0.41 and on 7 October was 0.50 (pooled overlap = 0.51). Overlap on all three dates was due primarily to the prescence of Chironomidae larvae in the diet of both species (Chironomidae larvae accounted for 93, 93, and 87% of the total overlap value over the 21 July, 26 August, and 7 October dates). Other items common in the diet included Cladocera and Copepoda.

Lepomis megalotis - Aplodinotus grunniens: Significant dietary overlap occurred over all periods examined between the longear sunfish and freshwater drum. The Schoener index for pooled data was quite high (0.9). The most common food item consumed was Chironomidae larvae which accounted for 98% of the pooled overlap value. Overlap was high for individual dates examined. On 3 August, the dietary overlap value was 0.93. Chironomidae larvae was the only common item consumed on this date and bothe species contained high mean relative volumes in their stomachs (longear sunfish = 100%, drum = 93%). The 26 August date yielded a Schoener index of dietary overlap value of 0.9. Again, Chironomidae larvae was the most common item consumed (longear sunfish = 89.8%, drum = 92.8%) and accounted for 99.8% of the overlap value. The only other common item consumed was Cladocera. On 7 October, five common items were present in the diet of these species. Chironomidae larvae again was the primary item in the diet (longear sunfish = 81.6%, drum = 84.5%; 96% of overlap). Other items common in the diet included Cladocera (longear sunfish = 1.1%, drum = 3.0%; 1.5% of overlap), Copepoda (longear sunfish = 1.1%, drum = 6.6%; 1.5% of overlap), Amphipoda (longear sunfish = 2.5%, drum = 0.5%; 0.7% of overlap), and adult Coleoptera (longear sunfish = 1.2%, drum = 0.1%; 0.3% of overlap).

Micropterus punctulatus - Stizostedion canadense: Dietary overlap was significant for pooled data between the spotted bass and sauger (Schoener index = 0.82). Dietary overlap varied over the three dates in which both species were collected (9 June, 24 June, and 21 July). On 9 June, the Schoener index of dietary overlap was 0.62. Both species contained approximately equal portions of fish in the diet (spotted bass = 61.1%, sauger = 61.5%; 98.5% of overlap value). The remaining portion of the diet of the sauger consisted of benthic insect larvae (Chironomidae larvae = 32.3%, Trichoptera larvae = 5.7%) whereas the remaining portion of the diet of spotted bass consisted of primarily zooplankton (Copepoda = 22.6%, Cladocera = 4.4%) with only a small portion of benthic larvae (Chironomidae larvae = 0.6%). This indicates a more benthic habitat being occupied by the sauger as opposed to a more pelagic lifestyle of the spotted bass. On 24 June, dietary overlap was 0.77. Again, fish were the most prevalent item in the diet of both of these species (spotted bass = 74.4%, sauger = 98.7%; 96.5% of overlap). Other items common in the diet of each species were Chironomidae larvae (0.5% for both), and adult Diptera (spotted bass = 6.2%, sauger = 0.8%). On 21 July dietary overlap was near the significant level with a value of 0.57. Fsih were the only common item in the diet of the two species (spotted bass = 57.5%, sauger = 100%). Spotted bass diet was much more diverse, with aquatic macroinvertebrates typically associated with aquatic macrophytes (Pennak 1978) making yp a large part of the remaining food volume (Corixidae = 17.7%, Odonata larvae = 24.2%).

Morone chrysops - Stizostedion canadense: Dietary overlap from pooled data for the white bass and sauger was 0.52 for the three common dates in which both species were collected (9 June, 24 June, 21 July). Overlap varied considerably over these three dates. On 9 June, dietary overlap was 0.54. Common items in the diet included fish (white bass = 16.1%, sauger = 61.5%), Chironomidae larvae (white bass = 35.9%, sauger = 32.3%), and Trichoptera larvae (white bass = 7.1%, sauger = 5.7%). The dietary overlap value for 24 June was 0.37. Common items in the diet for this date included fish (white bass = 37%, sauger = 98.7%), and Chironomidae larvae (white bass = 3.9%, sauger = 0.5%). Significant dietary overlap was found on the 21 July date (Schoener index = 0.63). During this date the only common food item found in the stomachs was fish (white bass = 63%, sauger = 100%). Although only two sauger were collected past 21 July (both of which contained only fish), overlap was extrapolated for these two species for the 26 August date based on presented data (for 26 August) for white bass, and on 21 July data for sauger as well as the diet of the two species collected after 21 July. Estimation of dietary overlap based on this procedure was 0.99. Although this estimation is extremely high it probably rivals the actual situation found in the Ohio River.

Analysis of Growth:

Growth analysis will be presented for the top 14 species in abundance from 1982 data. Table 32 provides a summary of the average growth per day in millimeters for those species examined.

Dorosoma cepedianum: Gizzard shad first appeared in 1982 samples on 21 July. On that date the average total length was 23.3 mm. By the date of our last 1982 sample on 7 October, gizzard shad had grown to an

TABLE 32: Average growth per day expressed as mm/day for Ohio River young-of-the-year fishes

SPECIES	mm/day	SPECIES	mm/day
Dorosoma cepedianum	0.74	*Carpiodes carpio*	0.95
Hybopsis storeriana	0.39	*Morone chrysops*	1.54
Notropis atherinoides	0.33	*Lepomis macrochirus*	0.10
Notropis blennius	0.28	*Lepomis megalotis*	0.39
Notropis volucellus	0.20	*Microp. punctulatus*	0.54
Pimephales notatus	0.22	*Stizo. canadense*	1.38
Pimephales vigilax	0.21	*Aplod. grunniens*	0.56

average of 85.9 mm. This translates into an average per day growth rate of 0.74 mm/day for the period examined. Highest growth (in mm/day) occurred between 26 August and 8 September when growth averaged 1.34 mm/day. Growth per day during the other periods examined included the following values: between 21 July and 3 August = 0.48 mm/day;

between 3 August and 26 August = 0.69 mm/day; between 8 September and 7 October = 0.80 mm/day. Period of maximum growth did not appear to be correlated with a change in diet, since gizzard shad maintained a steady diet of bottom ooze (91.7 - 100% of mean relative volume during those periods examined - see Dietary Habits section) over the summer period.

Relative to other geographical areas, gizzard shad growth was comparably slow. Purkett (1958) reports that in Missouri streams gizzard shad average 130 mm total length by the end of their first year. Bodola (1965) reported Lake Erie specimens averaged 140.5 mm standard length by the end of their first year. The comparatively slow growth of gizzard shad may be due to low caloric content of the benthic ooze. Pierce et al. (1981) cited poor organic content of benthic ooze consumed by gizzard shad as a possible explanation for slow adult growth found in an Ohio reservoir.

Hybopsis storeriana: (see Figure 5 for a plot of growth for the silver chub) Silver chub first appeared in samples on 21 July. Fish collected on that date averaged 31.7 mm total length. By 7 October, silver chub averaged 62.3 mm total length. Average growth rate over this period was 0.39 mm/day. Highest growth occurred between 26 August and 8 September when growth averaged 1.0 mm/day. Growth appeared initially slow. Between 21 July and 3 August, growth was only 0.06 mm/day. Growth increased in the period between 3 August and 26 August to 0.45 mm/day. In the period between 8 September and 7 October, growth again slowed to 0.21 mm/day. The period of maximum growth did not appear to be influenced by a change in dietary habits of this speceis, since dietary habits did not change significantly over the periods examined.

Little information is available concerning growth of the silver chub, especially young-of-the-year. Kinney (1954) reports that young-of-the-year from Lake Erie ranged from 26 - 80 mm total length. Trautman (1981) list ranges as from 25-76 mm total length for Ohio specimens.

Notropis atherinoides: (see Figure 6 for a plot of growth for the emerald shiner)

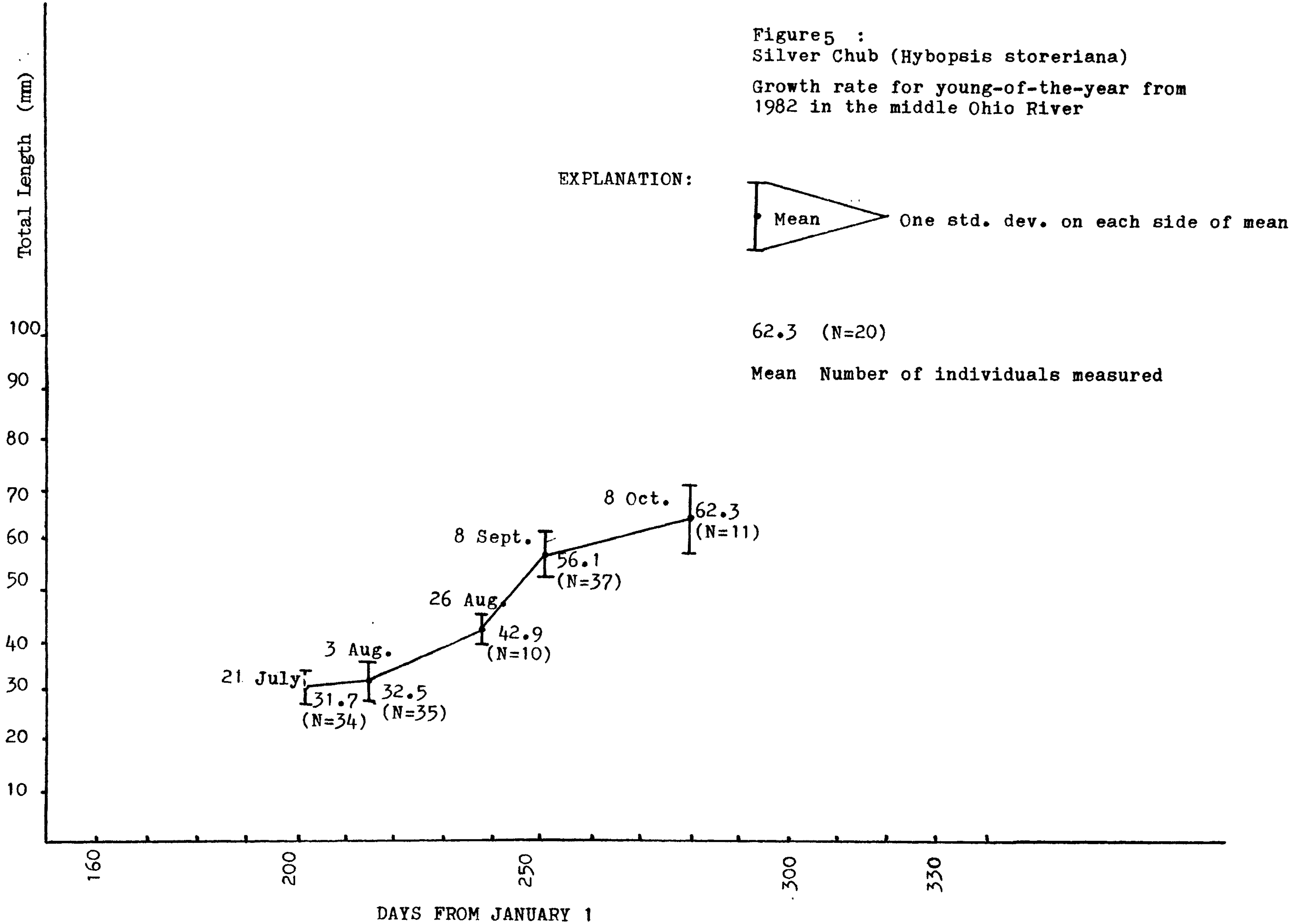


Figure 5 : Silver Chub (Hybopsis storeriana)

Growth rate for young-of-the-year from 1982 in the middle Ohio River

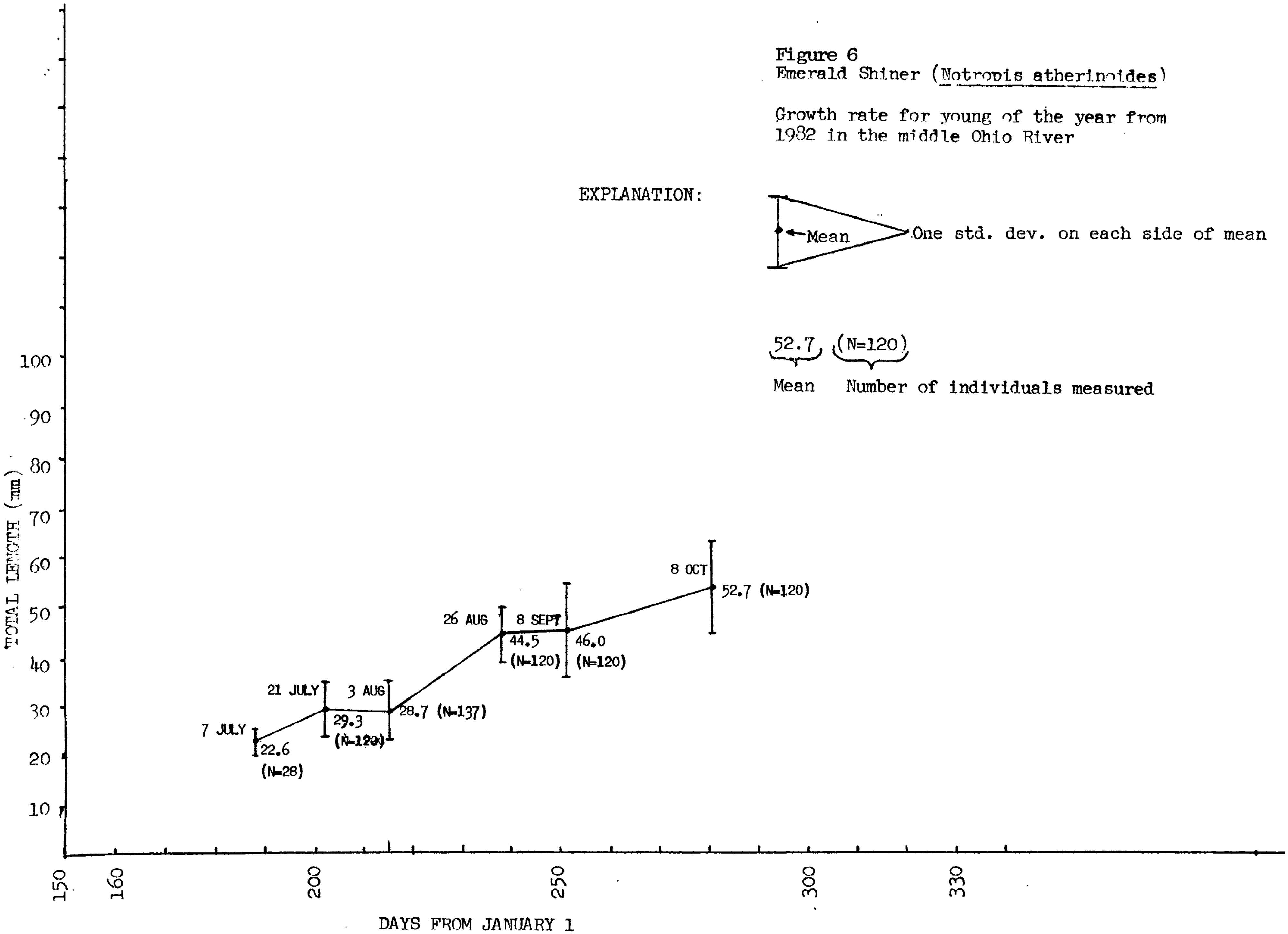


Figure 6
Emerald Shiner (*Notropis atherinoides*)

Growth rate for young of the year from 1982 in the middle Ohio River

Emerald shiner first appeared in 1982 samples on 7 July. They grew from an average of 22.6 mm total length to an average of 52.7 mm total length between 7 July and 7 October. This represents an average growth rate of 0.33 mm/day. Between-sample growth rate was variable. Between 7 and 21 July, growth was 0.48 mm/day. Between 21 July and 3 August, no increase in mean total length was found. Highest growth occurred in the period from 3 August to 26 August, when growth was 0.69 mm/day. Between 26 August and 8 September growth rate was slow, with an average of 0.12 mm/day. In the period from 8 September to 8 October, growth rate increased to 0.23 mm/day. The period of maximum growth did not appear to be influenced by a change in the dietary habits of this species, since dietary habits of this species did not change significantly over the summer period.

Emerald shiner growth reported here differs very little from previous studies. Trautman list total length ranges for October from 28-58 mm total length. In Wisconsin (Lakes Poigon and Winnebago), total length ranged from 41-53 mm in October. In Michigan, age 0 fish were between 30 and 68 mm total length. Lake Erie (1961) young fish were 61 mm average total length in September. In South Dakota, emerald shiners reached 63 mm total length (55% of adult size by the end of the first year of life, Fuchs 1967). In Lake Simcoe, Ontario, McCrimmon (1956) reported that young-of-the-year averaged 51 mm total length by mid-November.

Notropis blennius: (see Figure 7 for a plot of growth for the river shiner) River shiner first appeared in 1982 samples on 27 July. They grew from an average of 20.2 mm total length on 27 July to 41.9 mm on 8 October. Average growth rate during this period was 0.29 mm/day. River shiner exhibited variable between-period growth. Highest growth occurred between the initial periods examined, where daily growth rate was 0.63 mm/day. Growth rate decreased between the next period examined (3 August and 26 August) to 0.33 mm/day. Between 26 August and 8 September, growth was 0.28 mm/day. The period of maximum growth occurred at a time of a dietary transition in

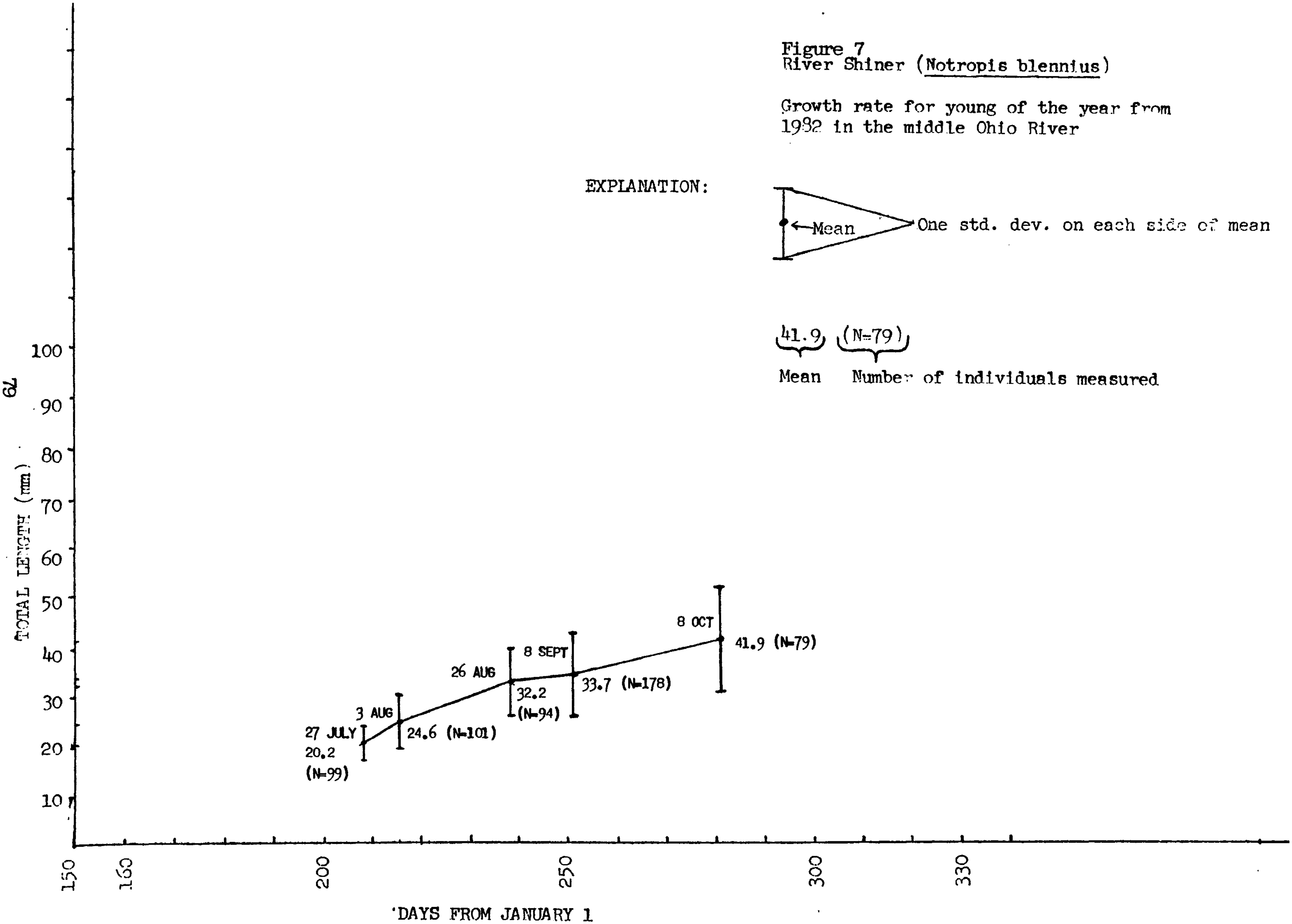


Figure 7
River Shiner (Notropis blennius)

Growth rate for young of the year from 1982 in the middle Ohio River

the river shiner. River shiner diet changed from primarily Copepoda and Chironomidae larvae on 21 July, to primarily filamentous green algae on 26 August.

Little information is available from the literature concerning growth of river shiners. To the author's knowledge this represents the first detailed examination of the growth of young-of-the-year river shiner. In the only other reference which mentions growth, Trautman (1981) reports young-of-the-year from 20-56 mm total length in October.

Notropis volucellus: Mimic shiner first appeared in 1982 samples on 21 July. They grew from an average total length of 16.5 mm to 31.8 mm total length between 21 July and 7 October. Average growth rate during this period was 0.20 mm/day. Highest growth rate occurred between the initial periods examined (21 July and 3 August) when growth was 0.55 mm/day. Between the next two periods examined (3 August-26 August and 26 August-8 September) the growth rate was relative steady (0.23 mm/day and 0.21 mm/day respectively). Between 8 September and 7 October, growth rate slowed significantly to 0.003 mm/day.

To the knowledge of this author, no detailed studies have been performed concerning the growth rates of young-of-the-year mimic shiners. This represents the first attempt to examine such specifics.

Pimephales notatus: Bluntnose minnow first appeared in 1982 samples on 3 August. This species grew from an average of 30.0 mm to an average of 44.2 mm total length between 3 August and 7 October. Growth rate during this period was 0.22 mm/day. Growth rate between the initial 3 August date and 26 August was 0.24 mm/day. Highest growth occurred in the period between 26 August and 8 September when the growth rate was 0.44 mm/day. Growth rate slowed between 8 September and 7 October to 0.10 mm/day.

Relative to other studies, bluntnose minnow growth for the Ohio River yielded little difference. Westman (1938) found young-of-the-year bluntnose minnows achieve a standard length of 37 mm standard length (approximately 42-43 mm total length) by December. Pflieger (1975) reports bluntnose minnow reach 24-47 mm total length by early November of their first year of life in Missouri streams.

Pimephales vigilax: Bullhead minnow first appeared in 1982 samples on 3 August. Average total length of initial samples was 27.0 mm. By 7 October, average total length had increased to 40.1 mm. Average growth rate between these periods was 0.21 mm/day. Growth was relatively constant between the first two periods examined (3 August-26 August and 26 August-8 September) with the growth rate of 0.26 mm/day and 0.25 mm/day respectively. Between 8 September and 7 October, growth rate decreased to 0.16 mm/day. Therefore bullhead minnow reached 89% of their total length by 8 September.

Other studies suggest similar growth rates for the bullhead minnow. Pflieger (1975) states that Missouri specimens reach a length of 24-55 mm total length by the end of their first year of growth.

Carpiodes carpio: Young-of-the-year river carpsucker were collected on only two dates, 26 August and 7 October. Based on these two dates, the growth rate fro this species was 0.95 mm/day. River carpsucker grew from 39.8 mm to 79.8 mm total length during this time.

Little information is available concerning the growth of river carpsucker. Pflieger (1975) reports that this species averages 80 mm in length by the end of its first year of life.

Morone chrysops: (see Figure 8 for a plot of growth for the white bass) Growth of white bass in 1982 was higher than for any other predatory species examined in this study. From the date of first capture on 9 June to last capture on 8 September, white bass grew from an average of 21.8 mm total length to an average of 161.7 mm total length; for and average growth rate of 1.54 mm/day. Growth rate in the initial period examined was relatively slow compared to the rest of the summer periods. Between 9

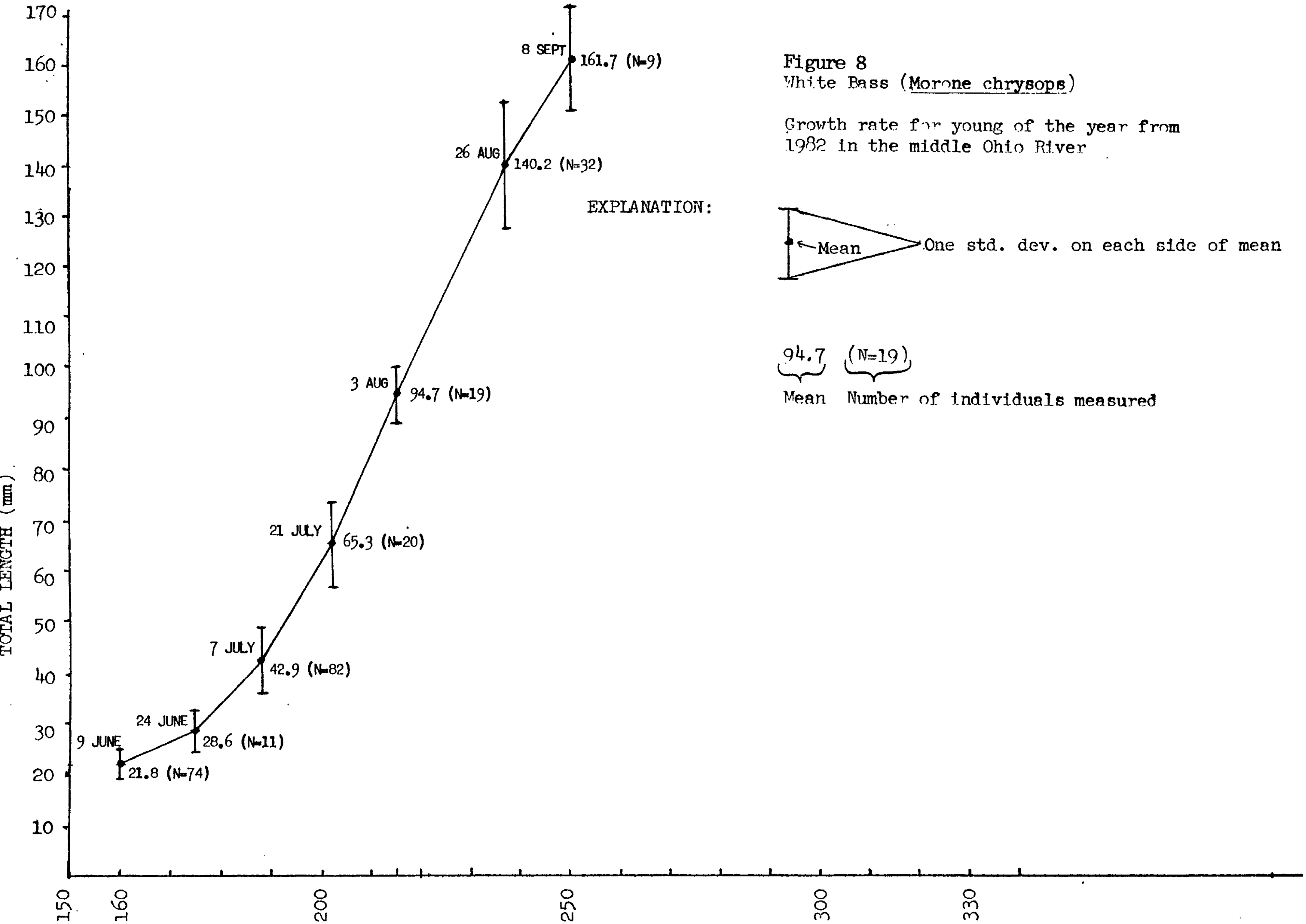


Figure 8
White Bass (Morone chrysops)

Growth rate for young of the year from 1982 in the middle Ohio River

June and 24 June, white bass growth rate was only 0.45 mm/day. Growth rate increased after this period and may be attributed to a dietary-shift from a planktivorous/insectivorous mode of feeding to a piscivorous mode (after 24 June, white bass were found to shift from a diet of primarily Cladocera, Copepoda and Chironomidae larvae to primarily fish). Betweem 24 June and 7 July the growth rate was 1.2 mm/day. Growth rate between 7 and 21 July was 1.6 mm/day. Highest growth rate occurred in the period between 21 July and 3 August, when the rate was 2.26 mm/day. Growth was also relatively high in the next period examined (between 3 August and 26 August) when the growth rate was 2.0 mm/day. Growth decreased between 26 August and 8 September to 1.6 mm/day. No white bass were collected after 8 September.

In terms of the average total length reached by 7 September (161.7 mm total length), white bass growth is comparatively high in relation to other geographical areas. Young-of-the-year from Lake Erie (Van Oosten 1942) reached only 119 mm total length at the end of age 0. In Oneida Lake, New York white bass reached 135 mm total length at the end of age 0 (Carlander 1977). White bass in Lewis and Clark Reservoir, South Dakota, reached 145 mm total length at the end of age 0 (Carlander 1977). Patriarche (1953) reports white bass reach a length of about 164 mm in their first year. In Bull Shoals Reservoir, Missouri, white bass were found to be 190 mm total length at the end of their first year of growth.

<u>Lepomis macrochirus</u>: Young-of-the-year bluegill first appeared in 1982 samples on 3 August. On that date the average total length was 19.8 mm. By 7 October, bluegill had grown to 28.2 mm total length. During this period the rate of growth was 0.13 mm/day. Growth rate was steady between the periods examined (3 August, 26 August, 8 September, and 7 October) at 0.13 mm/day.

Growth of bluegill in the Ohio River is lower than that reported for other areas. Beckman (1949) found bluegill reached an average total length of 43 mm by the end of their first year of growth in Michigan lakes. Snow (1969) found bluegills averaged 38 mm total length at the end of age 0. Trautman (1981) reports young-of-the-year ranging from 18-81 mm total length. Perhaps the backwater river habitat was not condusive to bluegill growth. In Missouri, Pflieger (1975) reports end of first year growth for bluegill was less for streams (35 mm total length), than for old reservoirs (40 mm total length), new reservoirs (70 mm total length), and ponds (55 mm total length). Lower growth therefore may be a function of habitat.

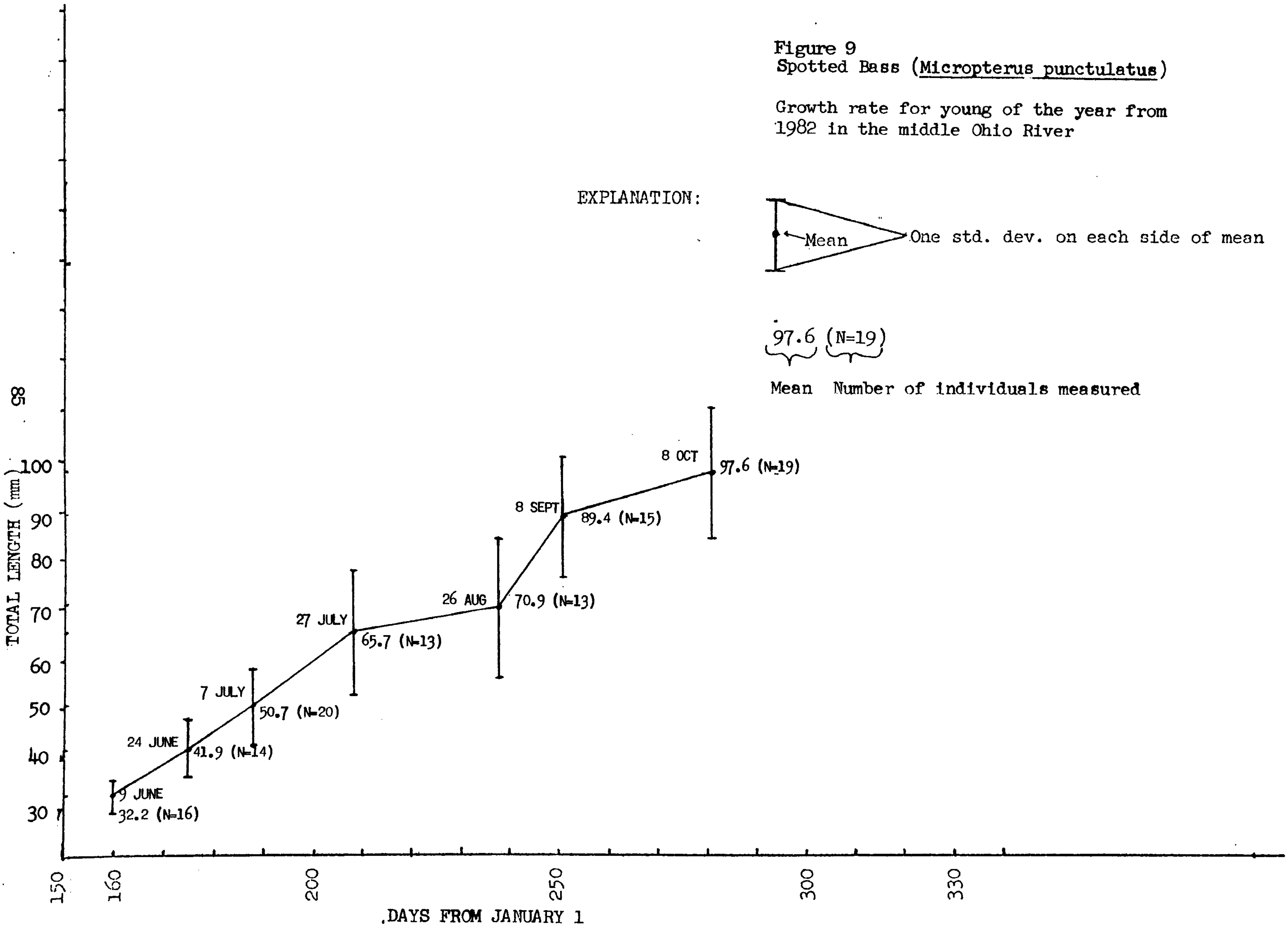
Lepomis megalotis: Young-of-the-year longear sunfish in 1982 samples first occurred on 3 August, at which time they averaged 16.7 mm total length. By 7 October, they averaged 41.7 mm total length. Growth rate for this period was 0.39 mm/day. Growth rate between 3 August and 26 August was 0.59 mm/day. Highest growth occurred between 26 August and 8 September when the rate was 1.0 mm/day. Between 8 September and 7 October, average total length did not increase, indicating little growth occurred past the 8 September date.

Several end total lengths are given for young-of-the-year longear sunfish from different parts of the United States. Most are lower than that reported in this study. In Missouri streams Purkett (1958) found that longear sunfish reach a total length of 32 mm. Hubbs and Cooper (1935) report that young-of-the-year longear reach a total length of 23 mm in Michigan waters. Trautman (1981) reports the total length range of young-of-the-year in general from Ohio as between 20-46 mm.

Micropterus punctulatus: (see Figure 9 for a plot of growth for the spotted bass) Young-of-the-year spotted bass were present in the first samples taken during 1982 (9 June). On this date the average total length was 32.2 mm. Between 9 June and 7 October this species grew to an average total length of 97.6 mm. Growth rate for this period was 0.54 mm/day. Growth rate was relatively steady between the first three periods examined (9 June - 24 June = 0.60 mm/day, 24 June - 7 July = 0.73 mm/day, 27 July - 7 July = 0.75 mm/day). Growth rate dropped significantly over the next period (between 27 July and 26 August) to 0.17 mm/day. Growth rate peaked between 26

Figure 9
Spotted Bass (<u>Micropterus punctulatus</u>)

Growth rate for young of the year from 1982 in the middle Ohio River



August and 8 September to 1.42 mm/day. Growth rate again decreased between 8 September and 8 October to 0.28 mm/day. Peak growth may have been attributed to an increase in fish in the diet (from 57% mean relative volume from those stomachs examined on 27 July to 100% mean relative volume on dates past 27 July).

Spotted bass growth from 1982 samples in the Ohio River was quite good in comparison to other studies presented for other areas. Average total length at the time of our last sample was 97.6 mm. In comparison, spotted bass from Big Creek, Illinois averaged 56 mm in August (average total length in this study in August was 70.9 mm). From the White River, Indiana, spotted bass were 76 mm total length at the end of age 0. Purkett (1958) reports spotted bass attained a length of 87 mm in the first year of life in Missouri. Age 0 spotted bass attained an average of 86 mm in the Elk River, West Virginia (Carlander 1977). The most similar size attained by spotted bass as reported in the literature occurred in Arkansas and Oklahoma reservoirs, where age 0 fish attained 97 mm total length. Attainment of relatively large size here in this study may be due to the abundance of forage fishes (emerald shiners primarily).

Stizostedion canadense: Sauger growth in the latter stage (past 24 June) is difficult to assess because of low sample sizes (n = 5 on 21 July, n = 3 on 3 August, n = 1 on both 26 August and 8 September). Based on available data, sauger grew from an average total length of 41.4 mm on the first date they were encountered (9 June) to 167 mm total length on 8 September (based on 1 specimen), for an average growth rate of 1.38 mm/day. Between date growth rates were as follows: 9 June - 24 June = 0.86 mm/day, 24 June - 21 July = 0.66 mm/day, 21 July - 3 August = 2.77 mm/day, 3 August - 26 August = 2.0 mm/day, 26 August - 8 September = 0.90 mm/day.

Based on the single specimen collected on 8 September, sauger growth is comparable with that reported by other authors. Vasey (1967) reports sauger average 145 mm total length in the Iowa section of the Mississippi River. Carlander (1950) reports that sauger average 168 mm total length in Lake of the Woods, Missouri. Sauger growth

FIGURE 1: PLOT OF GROWTH FOR FRESHWATER DRUM

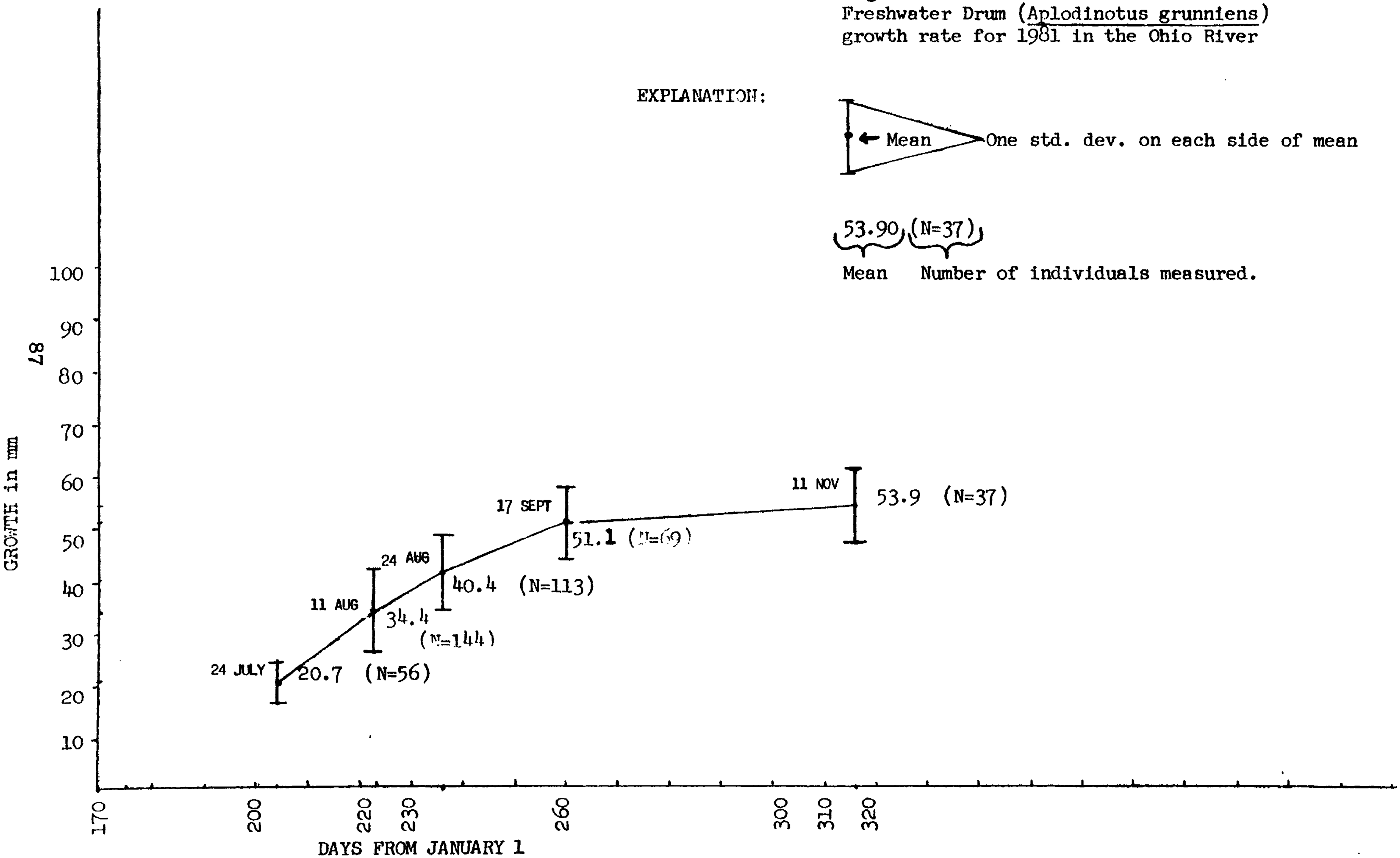


Figure 10
Freshwater Drum (<u>Aplodinotus grunniens</u>)
growth rate for 1981 in the Ohio River

does appear to be better than Lake Erie, where Dearson (1933) found saugers to average 99 mm total length at the end of age one.

Aplodinotus grunniens: (see Figure 10 for a plot of growth for the freshwater drum) Freshwater drum first appeared in 1982 samples on 21 July. At that date they averaged 35.1 mm total length. By 7 October, average total length was 78.4 mm. Growth rate during this period was 0.56 mm/day. Growth rate between 21 July and 3 August was relatively low at 0.28 mm/day. Highest growth occurred between 3 August and 26 August, when the growth rate was 0.77 mm/day. Between 26 August and 7 October, growth rate was 0.52 mm/day.

Several authors have reported on the growth of freshwater drum throughout the United States. Measurements from this study found the average total length of drum was 78.4 mm on 7 October. Relative to other studies, this value is low. Carlander (1977) reports that in Missouri river impoundments drum reach an average of 85 mm (Lake Sakajawea and Lake Francis Case) and 100 mm (Lake Oahe) by the end of age 0. In Lewis and Clark Lake, South Dakota, drum averaged 91 mm at the end of the year (Swedberg 1968). This average was based on data between 1956 and 1966. Data from upper Mississippi River navigation pools (Butler and Smith 1949) reports total length of drum ranged between 115-120 mm at the end of age 0. Edsall (1967) reports drum from Lake Erie averaged 99 mm total length in Late October. Purkett (1958) reports drum from Missouri streams average 110 mm total length by the end of their first year of life.

DISCUSSION

In terms of the water quality parameters examined, backwaters and mainstem margins differed little. Differences did occur in temperature, dissolved oxygen, and turbidity during initial periods examined, with backwaters having slightly higher values for these parameters. Higher initial temperature may have allowed earlier spawning in backwaters, although there are no clear-cut trends in the data which indicate this, such as earlier appearance of common species in the backwater habitat.

Backwater habitats supported a structurally more diverse fish community than mainstem margins. Only five species formed associations in mainstem margins (gizzard shad, emerald shiner, river shiner, mimic shiner, silver chub), whereas fourteen formed associations in backwater habitats (gizzard shad, silver chub, emerald shiner, river shiner, mimic shiner, bluntnose minnow, bullhead minnow, golden redhorse, white bass, bluegill, longear sunfish, spotted bass, largemouth bass, drum). Backwater habitats contained a greater number of species in significantly higher densities than mainstem margins. Diversity, a combination of the preceeding two parameters, was also higher in the backwater habitat.

Several areas need to be discussed concerning factors important in the disproportionately greater distribution of young-of-the-year fishes in the backwater habitat. First, the mainstem margins, although impounded, do have some current flow (ave. = 1200 m3/s). They represent areas which are relatively open and actually part of the river system proper. The species which were collected there in general tended to be more riverine in their habitat preference (Trautmam 1981, Clay 1978, Pfleiger 1978, Scott and Crossman 1972). The term riverine as used here implies these species are in general cited as occurring in large river systems with current . Those species include gizzard shad, emerald shiner, river shiner, mimic shiner, and silver chub. By contrast backwaters are observed to have little or no measurable current flow and therefore these areas are attractive to those species such as centrarchids which exhibit a preference for quiet waters.

Another factor important in the distribution of young of the year fishes is the amount of cover. Margins have little or no cover available. There attraction as nursery areas for those species found there probably lies in the fact that these areas are relatively shallow and offer protection from predators due to their shallowness.

However, the vast majority of young of the year prefer some type of cover for protection and herein lies one probable reason for the greater numbers of species found there. Several species of aquatic macrophytes are present in backwaters. In this study Ceratophyllum demersum, Polygonum persicaria, Myriophyllum spicatum, Lemna minor, Nuphar advena, and Nelumbo lutea were found. Areas which contain these types of macrophytes should offer protection from predators to young-of-the-year fish.

The availability of suitable spawning habitat may be another possible reason for the distribution of young of the year fishes in the Ohio River. The construction of dams on the Ohio River destroyed or limited most of the suitable spawning habitat available to adult fishes in the mainstem margins. That habitat which would be suitable for spawning in marginal areas is continually subject to wave disturbances from heavy barge and recreational traffic, which besides physical disturbances of the nest from wave action would also cause periods of erosion (or stirring of bottom sediments) and consequent covering of the eggs by silt and bottom sediments. Therefore what little spawning habitat that is left is subject to great disturbances leaving a very low probability of successful spawning. Backwaters, on the other hand, provide a relatively disturbance free environment. Although there is silt present it is not continuously washed around. Backwaters along the entire length of the Ohio River have long been suspected by numerous authors (Yoder and Gammon 1976, Trautman 1981, ORSANC0 1962, Anonymous 1974) of harboring spawning activity. Yoder and Gammon (1976) state that the most significant use of the backwater by the common species encountered in their study of the middle Ohio River was for the apparent spawning activity during spring. This was substantiated by the prescence of many ripe and gravid individuals in relative community abundance in significantly higher numbers than for any other time of the year in the backwater zone. Larval fish studies by Moller (1983) based on size class frequencies suggested a backwater breeding preference for the Cyprinidae, Centrarchidae, and Clupeidae. Miller et al. (1981) also found larval densities to be as much as 300% higher in backwaters than mainstems. Backwaters also usually have a feeder creek which enters them at some distance (usually 2-3 miles) above the confluence where the backwater enters the river. These areas represent potential spawning areas to a variety of adult species which reside normally in the open water (pool) habitats of the Ohio River. Such species include white sucker (Catostomus commersoni), golden redhorse (Moxostoma erythrurum), spotted sucker (Minytrema melanops), quillback carpsucker (Carpiodes cyprinus), white bass (Morone chrysops), and sauger (Stizostedion canadense). These fish are all considered riffle spawners (Trautman 1981, Pfleiger 1978, Scott and Crossman 1973) and could potentially utilize the riffle habitats in the feeder streams above the backwaters for spawning. Young are presumed to hatch and drift downstream with stream currents to the backwater areas where they reside for a period of time. This idea is substantiated by the data in this study. Young-of-the-year white bass were found in the backwater areas early in the year (June and July) and later in marginal (island) habitats(see Figure 2). Sauger are collected in high numbers only in the June backwater samples (see Figure 3) and virtually disappear afterwords from all samples. The same is true for quillback carpsucker which were collected only during June and July. For the other previously mentioned fishes, the ability to extrapolate that they spawned in riffle habitats above backwaters is not as clearcut. Golden redhorse were present in significantly higher densities in backwaters for the periods examined. Abundances of other species is deemed too low to judge as to the probability of riffle spawning.

Perhaps the last factor in the distribution of young-of-the-year fishes would be the food (forage) items available. To this author's knowledge, no comparisons have been made on the differences in insect or plankton types or abundance between backwater and mainstem habitats. Beckett and Miller (1982) investigated the importance of contrasting current on macroinvertebrate colonization of multiplate samplers in the Ohio River mainstem. This represents the only work to date which has been performed on insect populations of the river. Although no analysis on the quantity and types of food available to young-of-the-year fishes was performed in this study, certain parameters may be discussed about differences in the forage composition of backwaters and mainstem margins. As stated previously, backwaters are more diverse in terms of microhabitats available to young of the year fishes. The variety of substrates and aquatic macrophytes (heterogeneity of habitat) should provides an excellent habitat for many types of aquatic organisms, most notably insects. The influx of feeder streams into backwater areas might also provides nutrients to backwater areas which would stimulate plankton growth. Miller et al. (1981) cited high algal production in tributary backwaters as a factor responsible for high dissolved oxygen concentrations in backwaters (relative to mainstem habitats) as well as providing an increased food base for larval fish which hatch there. These characteristics are substantiated by the number of species found in backwaters versus mainstem habitats. Analysis of dietary (see Dietary Habits section of this text) habits of some of the young-of-the-year found there indicate a wide variety of food organisms are consumed by the fishes there. It is doubtless the number of species in backwaters is partially due to the greater variety of foods available.

The trophic structure of Ohio River young-of-the-year fishes can be divided into two separate entities based on the differences which occur in species composition between the two habitats. Because only five species commonly co-occur in mainstem margins the trophic structure is more simple than backwaters. Gizzard shad represented the only detritivore in this study. Omnivores included mimic shiner and river shiner. Emerald shiner was the only mainstem planktivore and silver chub the only insectivore. Upper level piscivores are represented by white bass, skipjack herring, and sauger. Although other species are most certainly represented in the trophic scheme of mainstems, these species represent the ones consistently found in this habitat. This rather low diversity in trophic structure is probably due to the uniform nature of the marginal habitat, which as mentioned previously provides little available resources and cover necessary for a variety of plant and animal life.

The trophic structure in backwater habitats is more diverse than mainstem margins. Again as in the mainstem margin, other species occupying similar trophic levels are certainly present but the species examined represent those which are consistently found in the backwater and therefore those which for the most part dominate the trophic structure of the community. Gizzard shad represented a detritivore. Several omnivores were present (river shiner, mimic shiner, bluntnose minnow, and bullhead minnow). These species consumed various proportions of detritus, zooplankton, insects, and periphyton. Zooplanktivorous fishes included emerald shiner and river carpsucker. Insectivorous species included drum, silver chub, and longear sunfish. One species, the bluegill, was found to be a combination insectivore/zooplanktivore. Three species were found to be upper level piscivores among those examined; the white bass, spotted bass, and sauger. These species were also found to occupy several positions in the food chain as they grew from small to larger size. At small sizes (approximately less than 40 mm total length), these species were primarily zooplanktivores/insectivores. With increased size they became primarily piscivores.

Competition for food was very important among several species of young-of-the-year fishes in the Ohio River. Trophic interactions occurred between eleven species pairs (ten total species) of young-of-the-year fishes in the Ohio River. These interactions occurred among those species which occupied the same relative position in the trophic structure of the Ohio River. Insectivores (drum, silver chub, and longear sunfish) all tended to have high dietary overlap between each other based primarily on the high relative volumes of Chironomidae larvae consumed by each. Two omnivores, bluntnose minnow and bullhead minnow, also exhibited high dietary overlap with these insectivorous species again based on the high relative volume of insects consumed by these species. Bluntnose minnow formed significant trophic overlap with drum and longear sunfish. Bullhead minnow showed high dietary overlap with the drum. Omnivores exhibited significant dietary overlap among themselves as well. Interactions were found to occur between mimic shiner and bluntnose minnow and between bluntnose minnow and bullhead minnow. Mimic shiner also formed a dietary interaction with gizzard shad which was due to high relative volumes of bottom ooze in the diets of each species .Significant dietary overlap occurred between spotted bass and sauger and between white bass and sauger. The majority of this overlap was due to high relative volumes of fish in the diet of these species.

A potential isolating mechanism may be operating to reduce potential competition between these species. Most species exhibited differing periods of maximum abundance. This staggering of abundance can act to alleviate the amount of pressure on a particular food item by a particular species (Nikolsky 1969). Species may utilize the same food items but because their abundance is staggered they are reducing direct one-to-one competition. Of the eleven species pairs which exhibited significant dietary overlap in the Ohio River, nine were found to stagger their periods of maximum abundances so that they occurred later or earlier than their mate in the pair. Those species pairs and their period of relative maximum abundance during the season (in parenthesis) included gizzard shad (early) - mimic shiner (late); silver chub (early) - longear sunfish (late); mimic shiner (late) - bluntnose minnow (intermediate); bluntnose minnow (intermediate) - bullhead minnow (late); bluntnose minnow (intermediate) - drum (early); bluntnose minnow (intermediate) - longear sunfish (late); bullhead minnow (late) - drum (early); longear sunfish (late) - drum (early); and spotted bass (early) - sauger (very early). Only the silver chub - drum and white bass - sauger represented competing species pairs in which periods of maximum abundance occurred at the same time.

Growth of young-of-the-year fishes in the Ohio River was in general comparable to data presented by other authors for other areas. Notably higher growth was found in the white bass and may be due to the abundance of emerald shiners available as forage to this species. Freshwater drum exhibited relatively slower growth relative to other reported data.

This study should help to establish the importance of backwater habitats to the survival of a major element of the Ohio River fish fauna. We can now begin to appreciate the role these habitats play in the overall biology of young-of-the-year fishes in the Ohio River. It is important that these areas are given special attention and protection from endangering development.

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